A Framework to Evaluate the Impact of Building Legislation on the Performance of the Built Environment:

The Case of Kuwait, a Master-Planned City-State

by

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ABSTRACT

This thesis focuses on the impacts of building regulations, in the form of building codes, on the development of an urban fabric. In particular, it investigates the role of building codes on a place that has an inherent sociocultural structure that manifests itself spatially. Using Kuwait City, a once traditional Islamic city, impacts of 'international' standards employed through master planning are explored at the neighborhood scale. Kuwait City serves as an ideal case study because of its historic Islamic and Arabic urban pattern that was derived from sociocultural customs, religious beliefs and terrestrial conditions. These influences resulted in a once cohesive city of a courtyard house typology, with narrow and shaded alleyways structured on longitudinal corridors of diverse land-uses promoting access and connectivity; however, the Minoprio, Spencely, and Macfarlane master plan of 1951 eradicated this close-knit urban fabric in favor of "modern" planning ideals which were loosely based on a fusion of Ebenezer Howard's Garden City and Clarence Perry's Neighborhood Unit. The 1951 plan called for a tabula rasa and relocation of homes from the historic city center to newly formed 'super-blocks' and 'neighborhood units'. Houses were built following strict building codes governing building heights, floor-area-ratio, and plot-line setbacks, along with other regulations. The Kuwait Building Code (KBC), introduced in 1955, is based on Western planning ideals that are far removed from the existing contextual complexities of Kuwait City.

This thesis will unpack the KBC by virtually translating this canonical text into its parametric spatial envelope, proposing a framework to evaluate its impact on the performance of the urban environment. Using urban modeling and micro-climate simulation tools, the virtual build-up of the rules will allow for a quantifiable examination to evaluate the putative "efficiency" of a modernist building code that

determines urban form, by considering multiple performance metrics. By objectively evaluating the role that the KBC plays in determining future urban quality, this research aims to make the case for building in enough space within the code to allow for a more diverse influence of performance indicators to promote a ‘resilient and sustainable’ built environment at the neighborhood level.

I dedicate this thesis to my wonderful family. To my parents Reyadh and Sawasan, who are the reason of what I become today and no words can express my gratitude; to my only sister Sarah who encouraged me to go on every adventure; to my wife Aysha who made it possible to complete this work and whom I am indebted to with my months far away from home; and to the twinkle in my eye, my daughter Shaha, who inspires me to grow and for being the new joy of my life. Lastly, and certainly not least, I dedicate this work to my late grandmother, Shaha, for her strong believe in the pursuit of academic excellence and to a promise nearly kept.

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Chapter 1

Introduction

1.1 Background

The transformation of the Arabian Gulf States from vast desert resorts rich with vernacular architecture to the so-called "Las Arabia" we see today exhibits an appropriate paradigm to examine the impacts of a 'universal' notion of urban standards imposed on an established society with unique built-up character. The apparent disconnect between the Arabian culture and imported urbanization standards is an issue that has historically plagued the region, and is evident in both the British influence in the nation-building period of the 1950s and the post-colonial eras of these nascent states. Concerns and reactions to regulated built environments are not new, and nor are they restricted to the Gulf region. Many have been examined qualitatively to analyze and document the impact of physical interventions imposed on spatial relationships at the cost of urban quality. Qualitative methods have been deployed to assay the "less quantifiable impact on the quality of life, ambience, neighborhood, and communal integrity" (Dandekar, 1986, p. 44).

The valuing of efficiency was the driving principle of 1950s modernists, and much of the literature studying modernist built forms has focused on assessing specific interpretations of efficiency, such as energy efficiency and efficient infrastructures. Although traditional built forms continue to provide instructive sustainable solutions they are found to be inapplicable to contemporary urbanism (Rashid & Ara, 2015). Despite some views to the contrary, there is a universal assumption that mainstream modernist designs and the building codes they have influenced, are necessarily more 'efficient' than traditional urban solutions. Though research has widely expressed how building legislation constitutes a major element in the shaping of the built environment, debates concerning its impacts have not received enough empirical testing of its results to further measure its performance and alleged efficiency. This project examines this long established debate and fills this apparent gap in the contemporary literature of regulating urbanism, using Kuwait as a case study.

“It was a difficult commission. We did not know anything about the Muslim world and the Kuwaitis wanted a city – they wanted a *new* city, hospitals, schools, housing and good communications … All we could give them … was what we knew” (as cited in Gardiner, 1983, p. 33). This was a statement, made thirty years after the 1951 Master Plan commission, by Anthony Minoprio, a planner and partner of the firm commissioned, illustrating the tensions between what the city needed and what the consultants and the city planners wanted. As the master plan was accepted and implemented, it called for the complete destruction of the once organic city made of adobe brick courtyard houses, narrow alleyways, and compact urban form in favor of large superblocks – called Commercial Business Districts (CBD), wide boulevards, and houses in the newly established ‘suburbs’. The master plan of Kuwait led to a deficient, fragmented and automobile dependent urban form. These problems are a direct result of the employment of the building code that followed the physical master plan and has been consistently grown and modified since it was first implemented in 1955. Kuwait also presents a radical case study, with its building regulations heavily concerned with land-use, which intensified their divorce from the urban context in which they operated. Today, Kuwait’s urban environment suffers serious problems that concerns both policy makers and the public, including pollution in all its forms, poor thermal orientation of plots impacting building energy consumption, and remarkably high traffic congestion costs (Al-Anzi & Khattab, 2010; UNDP, 2009, 2011). The current code regulating the urban landscape of Kuwait urgently requires further examination of the way it impacts on the city's physical environment and spatial quality.

1.2 **Research Questions and Significance**

This study stems from an effort to better understand, answer and add to the extensive literature questioning how building legislation constitutes a major element in shaping the built environment. What are these regulations and how can these regulations address contemporary urban challenges? What are the influencing factors that impact the built environment? How do design and standards affect "livability" and "sustainability" and what role do they play in determining future urban quality? The study aims to move beyond the theoretical to the tangible and serves as a model to better understand the interventions of regulations on urban form and formation and its subsequent impact on the physical quality using a quantifiable approach. Its findings help expose the products of the KBC, using performance simulations as a tool for generating higher level planning guidelines to help make decisions and facilitate decision-making processes. This will ultimately bring a new platform for building regulations to enter the process of urban formation as a positive determining factor.

1.3 **Thesis Structure**

It is important to first understand the causes and effects of building regulations more generally. For this reason the study begins with a review of the literature on The Regulation of Urbanism which can be classified under three overlapping and guiding areas. The first of these is *the theory of regulating urbanism,* followed by *regional place-responsive urbanism,* and finally *impact evaluation measures and metrics.*

The broad discourse of urban interventions, urban governance history and impacts explored in *the theory of regulating urbanism* provides the knowledge required to understand and further examine the finer focus of this study: building code implications on residential neighborhoods. It reviews the early purposes of urban regulation to assess the extents at which contemporary codes are simply inherited and lacking context. Secondly, *regional place-responsive urbanism* identifies the norms that once guided vernacular form in response to a particular geography, climate and culture. Thirdly, *impact evaluation measures and metrics* extracts the urban evaluative principles and applications employed in preceding literature to configure the calculus of simulation research, the subsequent research methodology deployed in this investigation.

It then investigates the Planning of Kuwait by using archival research through documents and textual materials on Kuwait's urban development to recognize and map the transition of its urban fabric from its "cohesive order" through the influence of international standards. That is to reveal the tensions that emerged from adopting 'universal' planning ideals that disregarded an existing coding system that reflected an Arab-Islamic social structure and cultural norms that were inherent to urban form.

To support the narrative study, a *Simulation Framework* is used to evaluate the efficiency of an urban-form-determining building code in a virtual platform. Issues that are caused by the KBC are further analyzed to offer quantified results that can then be used to better understand the current challenges that plague Kuwait City, and cities of the larger Arabian Gulf context which were planned using the so called "international standards".

This is an effective model to better understand how the KBC manifests itself on the ground, because of its ability to provide accurate empirical findings based on translated, collected and calculated numerical inputs.

Firstly, the simulation model simplifies the complexity found in the urban texture of Kuwait using archetypal forms and parcelization[1] schemes defined within its four[2] successive planning stages and governed by the KBC, as shown later in the paper. It will then deploy a simulation-based analysis using Grasshopper parametric modeling environment and *umi*, a Rhinoceros-based urban modeling tool, to evaluate floor-area-ratio, operational energy, and walkability (Reinhart, Dogan, Jakubiec, Rakha, & Sang, 2013) to defined products of the KBC.

The framework concludes with a simulation of microclimatic conditions using the parameters determined in the simplification process. A micro-level analysis of outdoor temperature was simulated with ENVI-met 4.0, the three-dimensional computational fluid dynamics model. Ideally, the results will be developed into an index that will allow for the development of better cities in Kuwait as defined by their livability and sustainability matrix. These indices aim to impact urban form in the Middle East in two ways: first, by allowing for the testing of codes before implementation, and secondly, and more critically, by allowing for the development of urban codes that are inherent and specific to this region. Such codes would echo the best aspects of the intrinsic traditional urban coding system, while also accommodating modern day technological advances, producing an urban form that is

[1] The process of subdividing or platting land into smaller parcels

[2] (a) 1951 - Minoprio, Spencely and Macfarlane, (b) 1967 – Municipality Development Plan, (c) 1970 – Colin Buchanan and Partners, (d) 1977 – Shankland Cox and Partnership

suitable for the natural and socio-cultural environment while equally accommodating people, transport technology and buildings to ultimately secure more positive outcomes.

Chapter 2

Narrative Framework

2.1 The Regulation of Urbanism

2.1.1 ***Theory of Regulating Urbanism*.** In planning literature, the term *comprehensive plan* is commonly used to refer to the basic plans that are prepared to guide urban development. Focusing on the regulatory aspects of the former process of top-down master planning, which are present and in effect to present-day, this section surveys the theoretical debates of environmental and social impacts resulting from urban governance and regulation in the different forms of comprehensive planning. It looks at the literature that presented how inherited building ordinances demonstrate insignificant connection to the current condition, paradoxically associated to its theoretical goals in warranting the adequacy of urban quality.

Theses debates concerning the inconsistency amongst the desired and realized values in urban standards are not new. In fact it dates back to Raymond Unwin in 1909 when he described building regulations as "needless harassment and restriction of really good building" (as cited in Talen, 2012, p. 175). Ben-Joseph (2003) also argues that these debates are not new but rather were brought into being as early as 1910 by Fredrick Law Olmsted Jr. in the Second National Conference on City Planning and the Problem of Congestion in New York, when he stated:

> There has been a decided tendency on the part of official planners to insist with quite needless and undesirable rigidity upon certain fixed standards of width and arrangement in regard to purely local streets, leading inevitably in many cases to the formation of blocks and lots of a size and shape ill adapted to the local uses to which they need to be

> put. Another instance is that of fixing a minimum width of street and minimum requirements as to the cross section and construction there of which make the cost needlessly high for purely local streets, and thus inflicts a wholly needless and wasteful burden of annual cost upon the people. (Ben-Joseph, 2003, pp. 1–2)

The growth of discontent with regulating urban formation during the 20th century stimulated the "current intense interest in coding reform" (Talen, 2009, p. 155). In contrary to "use-based" zoning came an approach concerned with the "rudimentary physical characteristics" (Katz, 2004, p. 19) of buildings. This approach was developed by Duany Plater-Zyberk & Company and applied in the master plan of Seaside, Florida, in 1982. The main concern was enclosure and to set organized mixture of the built environment based on form as an antidote to conventional zoning that long ignored the character of place. Such an approach promoted spatial definition by enclosure, spatial pattern by intensity, homogeneity by diversity and connectivity. It was recognized as a major development in zoning and later termed as Form-Based Codes: flexible in regulating uses but inelastic to the extent of controlling "sitting on the lot, building height, location of porches and outbuildings and how parking should be handled" (Katz, 2004, p. 20).

The term "smart growth" was later invented in the mid-1990's within a policy framework initiated by the state of Maryland, and in a relatively short period of time developed as one the most commonly used planning term (Levy, 2013). While matching the intentions of the "comprehensive plan", the term came to remedy its products and most notably the outcomes of suburban "sprawl" – a term coined by William Whyte in 1958 and ignited numerous studies in the attempt to gage and classify urban sprawl. A set of visual indicators was developed to identify sprawl that were also accompanied with functional indicators by Reid Ewing (1997). The visual indicators included: (1) leap frog or scattered development, (2) commercial strip development, or (3) large expanses of low density or single-use developments. The functional indicators of which Ewing also associated with sprawl were inaccessibility and open spaces that lack "useful public function" (1997, p. 109).

While the term "smart growth" developed to gain its dominance in the discussion of the discipline, and form-based codes valued to properly relate built forms to the urban context, Duany Plater-Zybrek & Company from another take responded with the development of the *SmartCode* manual (2001). The *SmartCode* is a set of Transect-based regulatory codes that proactively guides urban pattern by encouraging a desired type and quality of development rather than simply restricting what can be built (Talen, 2001). The transect is a normative theory entrenched in the works of Patrick Geddes, Ian McHarg, and Christopher Alexander (Bohl & Plater-Zyberk, 2006). It is a framework that identifies the set of human habitats in accordance to the degree of urban character in a cross-section ranging from rural to urban.

Ellis (2005) argued that the planning profession has a crucial role to play in transforming the practice of developing deficient, fragmented and auto-dependent developments to one of creating better aesthetic, functional, equitable and sustainable urban products using a set of effective methods. These include (1) *Site Analysis* to "respond and express local character"; (2) *Public Participation* to further interact with "real places and real people"; (3) *Methods for the Design of Cities and Regions* to fuse the longstanding "split between 'planning methods' and 'design methods'"; (4) Urban and Architectural Codes to "specify the ground rules for the incremental process if high-quality building"; and (5) *Evaluating the Built Environment* to asses and identify best and poorest practices. In a study of the relationship between cause and effect, *City Rules*, Talen (2012) discussed the impact of regulations on place in the United Sates facilitating two of Ellis critical methods – the evaluation of built environment and the urban codes. Using a narrative approach, the book clearly translated theoretical rules to their counter physical impacts on the ground. Talen was able to show how zoning was developed to deliver contrary realities than what was originally conceived; thus promoting inaccessibility, exclusion and waste.

As research resulting from the discontent of urban quality challenged urban rules qualitatively and provided alternatives it still calls for the need of a more informed approach to urban regulatory framework and growth patterns. Although debates concerning impacts of building regulations on urban form and the built environment have been widely expressed, it has not received an empirical testing of its products to further measure its performance and efficiency.

2.1.2 ***Regional Place-Responsive Urbanism.*** Much of the literature concerning the rapid urbanism that the Arabian Gulf Region has witnessed concurs on the notion of reinterpreting its traditional urban values. The evidence found within these investigations affirms the significance of not only understanding the physical manifestations of the traditional built environment, but also exploring how the urban environment was a response to the residents needs as a function as well as performance. Costa and Noble (1986) state that:

> Traditional solutions for urban design in the Arabic town were the product of a

> long period of experimentation in which the primary concerns were to mitigate the rigors of a hot arid climate and to foster a built form that provided an adequate environment for domestic and social life with attendant facilities for religious observance. (1986, p. 168)

Similar morphological principles resulting from a common set of cultural, physical and climatic factors developed the vernacular urban fabric of cities within the Arabian Peninsula. Traditional solutions of the Arab town were an end result of long-term experimentations in mitigating the severities of the arid climate by securing an adaptable threshold. Despite the distinctions in origins and growth patterns, the morphology of these traditional cities followed a model that reflected climatic and religious constrains that is governed by "an incremental and organic additive formation of parts" (Kiet, 2011, p. 44). Conversely, the Western model was governed by the separation of functions using a quantitative subdivision approach that created sectoral components within a dimension. Western subdivision models came out of the concepts of efficiency and progress within the industrial city incomparable to that of the vernacular Arab city. Al-Sallal (2004) explains how vernacular land use patterns followed an efficient hierarchal system of organization "providing appropriate functional spaces for both public and private zones and the required separation between them" (2004, p. 96). This sets the fundamental difference between the modernist and vernacular notions of efficiency; the former was governed by perceptions of efficiency in spatial *usage* and the latter by spatial *hierarchy*. Also, the spectrum of privacy and public space in traditional urbanism was facilitated through levels that are sequenced by streets of which bind the different quarters of the city together. It is important to note that the aim in analyzing the vernacular Arab town is not to naively copy its geometry and the like, but to develop planning theories supported by regulations to renew the dialogues between urban form and the physical environment and cultural realities.

In highlighting the evidence of Shari'ah (Islamic Law) as the determining mechanism in the morphology of these traditional cities, Ben-Hamouche (2009) explains that the urban fabric was a product of resulting endogenous activities. He further justifies the complexity of the urban pattern as an outcome of successive activities and informal regulations that convey both age and maturity of the city. It is clearly visible in the scale of a residential unit typology when subject to systems subdivision. As found in the inheritance commandments of Shariah, the traditional typology responded compatibly to unit fragmentation and undisturbed to the adjunct functional components such as corridors and staircases, for example. The concepts and principles of Islamic law governed the rationale of such growth and change process (Hakim, 2008). In Hakim's investigations of Islamic codes, he used Isa bin Musa al-Tutaili's (or Ibn al-Imam) treatise of building laws and found that the underlying goals was to maintain the built environment in an equitable equilibrium in the face of growth and change. What is remarkable, he explains, is how the traditional coding system acknowledged sequential development concepts that replicated the modern day phenomenon of *Emergence* leading to complex "models of sustainable natural process" (2008, p. 39). Hakims findings were also evident in Sabbars (1971) writings about the urban phenomenon in traditional infilling practices which states:

> By the use of design disciplines derived from the Arab-Islamic architectural tradition for infilling, and by paying close attention to the qualities of surrounding buildings, better and more sensitive design can be achieved for new buildings. A town is a living thing and is continually changing, and its

> vitality and interest lie in the juxtapositioning of different periods of time as expressed by their architecture. (1971, p. 55)

The resulting complex pattern is a creation of repeated residential clusters in form of interlaced and lively cellular blocks marking an organic order of urban elements that vary in size. Ben-Hamouche also discussed how the traditional activities were privately or publicly facilitated, having the former based on freedom and the latter on public interest. He later argues that such distribution of roles are ought to be imported back to the present cities of the Gulf to "correct the anomalies in the regulation system such as the over-empowering of public institutions and the ever-growing informal sector" (2009, p. 33).

What underlies the location of traditional Arab settlements, similar to most cities, is the availability of natural resources, logistical commercial networks, and in some cases the consecration of locales. The internal structuring processes, as termed by Bianca, and the concept of order produced the "ubiquitous archetype of traditional Arab urban form" (Bianca, 2000, p. 141). Shiber (1964) relates the typical Arab town to that of the Medieval European town in terms of it anatomy . He explains that in its basic structure, the core was the mosque as a dominant architectural feature replacing the cathedral and a "maidan" supplanting the church square. The land-use pattern at this urban center "focused on a multifunctional core structure enveloping or at least partially surrounding the mosque by different layers of interconnected souqs [traditional bazaars]" (Bianca, 2000, p. 142). Souqs were the center of commerce during the centuries of regional maritime trade.

Due to its geographic location, the Arabian Peninsula served as the arterial trade passageway between India, Persia and North Africa. The souq from the early 1900's was a stretch of open space containing a popular market with thriving trade of agriculture and vast commodities from gold to spices. Commonly centered in the vicinity of ports/settlements, they were mostly uncovered open-air markets that used effective vernacular architecture methods to meet modest comfort levels despite the barren and inhospitable environment of the region. Narrow minor corridors allowed enough mutual shading with an orientation towards the coastal prevailing winds tunneling adequate volumes of sea breezes to its centers. Souqs back then incited the economic activity of the region not only with foreign imported goods, but also with products of local fishing, pearl diving, nomadic herding, and various indigenous crafts and commodities. Such ancillary activities were interlocked in their physical form and were never arranged with pre-set arithmetic measures but more towards the associated spatial functions that are modeled in response to social and physical constraints.

The central facility is connected to the remainder of the settlement's dimension with major carriage roads that stretch commercial frontages in a linear form down to the boundary walls. The extension of commercial activity grew to form interlaced land-uses resulting with accessible districts. Behind these commercial facades are residential clusters accessed through crossings of narrow alleyways at the major spines. The underlying principal of hierarchy and complexity in the circulation network and function between main carriage roads and secondary corridors conformed with the resident's needs. Responses to normative social customs, cultural norms, and terrestrial conditions formed a physical arrangement of an urban setting that is low in height, introverted in character and densely clustered. Buildings were built to the property lines with no existence to concepts of setback and a shared boundary was a common feature that helped reduce the exposure of surfaces to direct solar radiation.

In the rare narration by Raunkiaer, the Danish explorer, in 1912 of his camelback journey through Arabia; part of a residential cluster in Kuwait was described as:

> [U]sually only one storey [*sic*] and all are of sundried clay. The window openings, or rather the air and smoke holes in the walls, hardly ever give on the street. The doors, of which each house has the fewest possible, are kept fastened. The clay for houses comes from south and east of the town, where in consequence the ground is all uneven and full of holes. Clay is dug out anywhere a man happens to fancy or where his donkey has minded to stop. When the panniers on the donkey are full he is urged back to town, where the clay is soaked with water and kneaded with straw and twigs into a good cohesive mixture with which the houses' walls are luted [*sic*] up.
>
> The houses all have fiat roofs from which gutter pipes project into space at intervals. When once in a long while it happens to rain, the water from these gutters just about hits the middle of the lanes and this, added to the traffic along them, makes a trough down the centre [*sic*]. The streets and lanes are, however, conspicuous for cleanliness. They vary from two to six metres [*sic*] broad and in the main are laid out at right angles to the coast, with little frequented linking crossways, and by Oriental standards are not particularly crooked. (Raunkiaer, 1969, p. 51)

Although traditional and contemporary urban development practices are both governed by codes and customary laws, their impact due to their contrast in the fundamental understanding of the urban production process is what makes them differ. Hakim (2008) explains that proscriptive governance, as found in traditional codes, provides a template that defines a set of meta-principles under which urban development process responded freely. It therefore prevents products of uniformity and sameness by permitting diverse physical forms with a distinct urban identity as a result of the common underlying goals and intentions. Presently practiced coding systems represent prescriptive rules that are generally directed from a central authority. Such authoritative directions in urban creation tend to inhibit indigenously inspired solutions to local problems and often results with undesired uniformity. Contemporary building codes act as limiting factors to the culture encrypted within local built forms that were framed by traditional practices and customary laws.

Despite the harsh living circumstances, of limited natural resources as well as thermal discomfort, the vernacular structure of the cities sheltered their growing populace by securing maximum amenity. A proper understanding of the methods employed by people of limited resources and challenged by climatic severities is required to expand on the overlooked principles of spatial organization, physical expression, and the associations conditioned with cultural and climatic needs. Its comprehension and recognition allows inventive transformations of traditional responsive urbanism to reconcile the extraneous developments within the region that is imperative for the development of schemes that assures authentic urbanism.

2.1.3 ***Impact Evaluation Measures and Metrics.*** As much as standards for good urban form vary in scale and relative priority, so does its evaluation approaches. The pursuit of optimal urban forms has "fostered an alliance among a number of interrelated movements: historic preservation, downtown redevelopment, environmentalism, visual quality, public transit, bicycling, and pedestrianism" that "call for a reversal of standard development trends" (Talen, 2005, p. 207). Empirical studies investigating the performance of urban form variables are often founded upon environmental assessments and their conclusions are designed to foster sustainable developments. Performance indices of sustainable urban form – defined as efficient relationships of patterns and structures of urban elements – differ mainly due to the absent consensus of common attributes, as well as the contrasting values across different scales (UNEP, 2012). Despite the lack of concurrence among the disciplines towards an integrated performance matrix, a general concept is common and frequently found in the literature pertaining to the physical structure of desired urban forms.

Urban form assessments in environmental terms, collectively known as ecologically sustainable developments [ESD], are conducted over a wide range of spatial scales. It is however emphasized at the micro (single building) and macro (regional) scale, giving less attention to the meso scale (Hurley & Horne, 2006; Wang, Li, & Gao, 2016). Also, the extensive assortment of indicators as developed by the alliance of disciplines presents a current challenge for a universal platform. Within the potentially integrated metrics, is an assurance of the development of an interdisciplinary index that assesses the performance of urban form within the different scales with a global consensus (UNEP, 2012).

Irrespective of the scale at which the assessment is applied, two methodological approaches are implemented when developing sustainability indicators. That is largely based on typifying current built environment status using either existing data or a theoretical classification method, where data is one of many considered aspects

(Fujiwara & Zhang, 2005; Niemeijer, 2002). According to Fujiwara et al., the latter is known as a "data-driven approach, which argues that data availability is the central criterion for indicator development and data is provided for all selected indicators" and the former is termed as a "theory-driven approach, which focuses on selecting the best possible indicators from a theoretical point of view" (2005, p. 4353).

The work carried out by Lynch et al. (2011) defines indicators as quantitative measures that can also encompass other forms of evidence with more qualitative assessments. It also explains that indicators provide both a forecast and current standing in the sustainability context and are subject to the determinations of the developing alliance. The report further affirms the inevitable subjectivity of an indicator system through the preordained 'conceptual framework' guidance. Lynch et al. state that a conceptual framework defines:

> [T]he value-judgments embodied in the paradigm under scrutiny (Bell and Morse 2008). Some indicator systems include composite indicators or indices created through aggregation of data while others introduce social science results through survey research, sometimes employing Likert scales that offer more qualitative information. (Lynch et al., 2011, p. 9)

As mentioned earlier, the different approaches have been addressed to different spatial levels. Wang et al. (2016) explain that ESD assessments at the regional scale have been widely applied. Their paper abridges empirical studies within the (1) regional scale and the (2) metropolis level as: environmental impact assessments; strategic environmental assessment [SEA]; environmental quality assessment; objective-lead SEA; environmental efficiency assessment; and the environmental performance assessment.

Only few, assessment approaches are applicable or have been applied at the (3) meso scale. As investigated by Sharifi and Murayama (2013), current Neighborhood Sustainability Assessment (NSA) tools perform poorly in terms of coverage in sustainability aspects, with shortcomings in weighing, scoring and rating. They further explain that such tools are better performing in terms of applicability within the broader planning framework. Recently, the US Green Building Council (USGBC), in partnership with the Congress for the New Urbanism (CNU) published LEED for Neighborhood Development (LEED-ND) as a tool for precinct scale developments to produce a "national set of standards for neighborhood location and design based on the combined principles of smart growth, urbanism and green building" (as cited in Hurley & Horne, 2006, p. 4). Similarly, BREEAM Communities was developed to expand on the assessments of single buildings.

On the other hand, several different approaches were developed as tools to perform assessments at the (4) building level scale. Examples of such tools include Building Research Establishment Environmental Assessment Methodology (BREEAM), Comprehensive Assessment System for Building Environmental Efficiency (CASBEE), Leadership in Energy and Environmental Design (LEED), and National Australian Building Environmental Rating System (NABERS).

Currently, and at the precinct scale, a thematic analysis of the literature illustrates a set of significant physical factors that contribute to desired urban forms of reduced negative externalities. At the same time, it is acknowledged that a common conceptual framework, which demonstrates the lack of agreement on the single most desired urban form in the context of sustainability, is absent. Jabareen argues that the lack of agreement disallows studies to "evaluate whether a given urban form contributes to sustainability or to compare different forms according to their contribution to the sustainable development objectives and agenda" (2006, p. 39). Urban compaction, as a physical factor, offers a large consensus among scholars in its importance to attain sustainable urban form. The literature discussing typologies of compact urban forms generates a cyclic dialogue of its positive externalities: efficient intensification (Carl, 2000; Jenks, 2000; Talen & Cliff, 2002); traffic and land degradation (McLaren, 1992); urban transport energy use and the associated emissions (Anderson, Kanaroglou, & Miller, 1996); building energy consumption (Ewing & Rong, 2008); air quality (Stone, Mednick, Holloway, & Spak, 2007), to name a few.

Conversely, Neuman (2005) argues that contentions of compact urban forms to achieve the goals of sustainable development is flawed. He instead asserts that considering urban form as a "processual outcome of urbanization" (2005, p. 23) guarantees successful attempts in realizing the desired goals. Also, Gordon and Richardson echo a similar argument towards promoting compact cities (Gordon & Richardson, 1997).

Compact urban form structures also promote physical contiguity and connectivity, which indubitably appears as an important design concept concerning sustainability. It relates to the notions of resource inputs and by-product outputs showing stronger correlation with landscape connectivity and resilience (Ahern, 2011; Andersson, 2006). Ahern states that:

> When an urban landscape is understood as a system that performs functions, connectivity is often the critical parameter – and the lack of connectivity is

often a prime cause of malfunction or failure of particular functions… Connectivity is arguably a primary generator of sustainable urban form – built around blue-green networks that support biodiversity, hydrological processes, pedestrian transportation, climatic modification, neighborhood identity and aesthetic enhancements. (Ahern, 2011, p. 342)

The literature also encompasses physical structures that promote passive design strategies and use ambient energy sources as central to achieving sustainability. These strategies use sun, wind and light as influences to generate form rather than restrain it. Despite the advances in technological innovations towards active systems, Ochoa and Capeluto (2008) persist with applications of early passive design strategies as a principal within the design framework that can be later enhanced with intelligent devices. The design parameters within buildings are able to affect the urban microclimate owing not only to the physical mass per se, but to the human behavior and activities it shapes. Yannas (1998) outlines six parameters to be considered in the physical framework:

- *Built form* density and type, to influence airflow, view of the sun and sky and exposed surface area.
- *Street Canyon* width-to-height ratio and orientation, to influence warming-up and cooling processes, thermal and visual comfort conditions, and pollution dispersal.
- *Building design* to influence building heat gains and losses, albedo and thermal capacity of external surfaces, use of transitional spaces.
- *Urban materials and surface finishes* to influence absorption, heat storage, and emissivity.
- *Vegetation and bodies of water* to influence evapotranspiration and

evaporative cooling process on building surfaces and/or on open spaces.

- *Traffic* reduction, diversion, rerouting to reduce air and noise pollution, and heat discharges. (Simon, 1998, p. 43)

The layout of urban elements out of the boundaries of a building such as block size and shape, configuration, and street patterns are able to make optimum usage of ambient energy sources. Owens (1992) cautions against understating "implications of built form and of the ways in which siting, orientation, layout and landscaping can make the optimal use of microclimatic conditions" (1992, p. 92).

From the literature reviewed above, it can be seen that available assessment tools and frameworks largely tend to be prescriptive solutions rather than comprehensive in evaluating the intended and actual performance of urban environments at the precinct scale. In exploring the nexus between urban form and key performance indices, scholars and practitioners conveyed their concerns from a wide range of standpoints determined by specialty and discipline. The available scholarship framed the performance metrics selected for this research to envelop the extensive discussion on urban performance, ranging from competence in density, operation and microclimates (see section 4.0).

2.2 **Planning Kuwait**

Intrepid sailors making a living from fishing and pearl diving have inhabited the site of the present capital of Kuwait since the early eighteenth century, with a very limited supply of potable water obtained through shallow terrestrial wells. The local population of about 10,000 fluctuated in reaction to the different seasons of caravan trading and pearling fleets (Abu-Ayyash, 1980). By the end of the eighteenth century, the Ottoman disputes in Basra fortuitously redirected maritime traffic to utilize Kuwait’s seaport, allowing it to thrive commercially and receive its first intercontinental recognition from the neighboring states and the European colonizing powers. Kuwait’s subsequent strategic importance as a port for central Arabia sanctioned it to become a vital waterway to British-controlled India. This, coupled with the desire to break away from Ottoman rule, led to the signing of the 1899 Anglo-Kuwaiti Treaty in which Great Britain offered protection to Kuwait when needed in return for access to the waterway. The distressed socioeconomic status of a community contingent on traders, boat-builders and fishermen was further compounded through the Great Depression of the 1930s, while at the same time, the development of cultured pearls negatively affected the pearling industry. The latter caused a drop of public revenue and expenditure, to under £50,000 British Pound Sterling in 1954 (Monroe, 1954). It was only after oil seepages in the deserts caught the attention of Westerners at the turn of the twentieth century that the socioeconomic scene revolutionized.

The promise of oil instigated an incessant rush of oil-concession agreements throughout the Middle East, paving the way to revolutionize the Arabian Peninsula. The first was the 1901 D’Arcy Concession between William Know D’Arcy and the Shah of Iran. Rulers of the region began to negotiate with the British Government and major oil companies of that time for exploration concessions in the desert principalities of the Arabian Peninsula. An agreement signed with the British Government not to grant any concessions except to companies appointed by them ruined several other negotiations attempted by different nascent oil companies asking for concession agreements. After World War I, interests in petroleum steadily increased, leading to great pressure from the United States on the British

Government to provide equal negotiation rights to non British oil companies. By 1932, Britain agreed to the request of an 'open door' policy in Kuwait, where the Anglo-Persian Oil Company (APOC) joined America's Gulf Oil Corporation (GOC) to form the Kuwait Oil Company (KOC) for the sole purpose of negotiating Kuwait oil concession agreements. Two years later, the Kuwait Oil Concession Agreement was signed with KOC, transforming a state-income totally dependent on sparse revenue provided by local economic activity to an oil exporting industry.

> "'IN THE NAME OF GOD THE MERCIFUL. This is an AGREEMENT made at Kuwait on the 23rd Day of December in the year 1934 corresponding to the 16th day of Ramadhan 1353 between his Excellency Shaikh Sir Ahmad al-Jabir as-Subah, Knight Commander of the Most Eminent Order of the Indian Empire and Companion of the Most Exalted Order of the star of India, the SHAIKH OF KUWAIT in the exercise of his powers as Ruler of Kuwait on his own behalf and in the name and the behalf of his heirs and successors in whom is or shall be vested for the time being the responsibility for the control and government of the State of Kuwait (hereinafter called "the Shaikh") and KUWAIT OIL COMPANY LIMITED, a company registered in Great Britain under the Companies Act, 1929, its successors and assigns (hereinafter called "The Company")'". (As cited in Gardiner, 1983)

With the outbreak of World War II, planning for oil development was halted due to the lack of the required heavy machinery and immense quantities of steel, which were not available at that time. In 1946, the oil development picked up again, being carried out efficiently using Western scientific knowledge, but facing executional difficulties due to the harsh environment of the barren desert. To overcome such setbacks and cope with the short supply of materials in the immediate post-war years, oil development plans were performed in two stages: immediate improvisation in the short term, followed by the installation of a permanent scheme (Southwell, 1953).

After the development of the petroleum industry, state income started experiencing steady growth. In less than two decades, it reached around £50 million (in 1954 British Pound Sterling). Such developments were associated not only with urban growth but population growth as well, due to the heavy dependence on foreign labor. Strong state returns empowered the then ruler Shaikh Abdullah AlSalim (r. 1950-65), with influential delegations to his ministers of the budding welfare state to invest in modern industrial apparatus to secure and serve its citizens' needs. The sharp increase in population, the rapid unplanned urban growth, and the city expansion combined to demand planning activities. The first master plan of the city was commissioned in 1951 to the British town-planning firm Minoprio, Spencely, and Macfarlane (MSM). Jamal (1973), a Kuwaiti planner, wrote an article in *The Architect's Journal* harshly criticizing the government then, and the plan of MSM by labeling it as "*the first mistake*". He further elaborates:

> The Government, inexperienced in such matters, found it necessary to plan more scientifically and to take foreign professional advice. Early in 1951, a town plan accompanied by a short report had nothing to work on other than aerial photographs and the fact that the work was done in far away London compounded the problem. The resulting plan brought about a situation of grave concern.

Two years after the commencement of the plan, Macfarlane (1954) wrote in the *Journal of the Town Planning Institute* explaining the Master Plan of 1951. Macfarlane explains that planning "for such an area presented special problems", one of which was that "the town has never been mapped". Although an aerial survey was undertaken (see Appendix A) to remedy that "problem", the true and unresolved problem was to map the current society and the determining factors which had produced that established urban environment. As Mahgoub (2002) puts it, "no formal building regulations existed before the implementation of the new planning of Kuwait in 1952", however it was practiced "according to acceptable socio-cultural norms" (p. 50). The proposed plan was concerned with the importance of new and improved road systems, land-use assignment, town center beautification, open spaces and a green belt (MacFarlane, 1954). Albaqshi (2010) explained that the green belt, which followed the outline of the demolished vernacular city wall, separates the new town center from the new neighborhoods units. The "improved" roads came in a modified width that resulted in the brutal destruction of a cohesive urban fabric, paving the roads for the intrusion of the motorcar that destroyed the traditional ways of life of most Kuwaiti people. As emphasized by Talen (2012), the increasing paranoiac need to control, sort and exclude, is distinctly evident in MSM's central concerns of the master plan. The first sign of urban governance appeared within the attached report of the master plan, and this will be further examined in the two following sections (2.2.1 and 2.2.2).

2.2.1 ***Tracing the Kuwaiti Building Code.*** Kuwait provides an appropriate case study to examine a then local urban fabric that was eradicated in favor of a universal idea. It is not only that the aforementioned imported urban frameworks were put into place despite originating from a different urban condition; more importantly it was an “imposition of western technology onto an established Arab society” (Jamal, 1973, p. 1453). In fact it was a society that had established a closely packed urban pattern that once retained connectivity, pedestrian orientation, land-use diversity, enclosure, and small blocks, and certainly did not require an irresponsible planning approach that neglected such context.

As proclaimed by Mahgoub (2007), “the city center, once a place where families lived, shopped, worked and played, was foreordained a commercial district and residents were shifted to Western-style family homes and apartments in the new neighborhoods” (p.72). To maintain this imposition of “Western standards” and remedy the “primitive condition” of the city, MSM also found it “necessary to control the way in which buildings shall be erected, their height, the amount of land which each can occupy, the distance between buildings and the width of development roads giving access to houses” (Minoprio & Spencely and P.W. Macfarlane, 1951, p. 31). This was the first attempt towards the control of urban development practices in Kuwait, replicating English and non-native standards into the Kuwaiti context. What compounded the problem, Jamal explains, is the “fact that the work was done in far away London” (1973, p. 1453) and accordingly resulted in controls which were a response to difficulties in a completely different natural and cultural context.

The report of the 1951 Master Plan had not set the governing urban codes, at that stage MSM saw it necessary to “only call attention to the need for such rules; their preparation will require detailed study of local conditions” (Minoprio & Spencely and P.W. Macfarlane, 1951, p. 31). Apparently, the advice was favorably considered and with the establishment of the Building and Permissions Affairs within the Technical Department at Kuwait Municipality in 1954, there followed a mature document titled

Nitham AlBina' 1955 (The Building Code 1955) [Figure 1]. The code that developed from a recommendation in several sentences within the 1951 Master Plan report grew into a forty-one-page document comprising of eight broad sections:

Section 1: General Provisions Relating to Permits

1.1 Ban of building without permit

1.2 Permitting terms

1.3 Issuing a permit

Section 2: General building regulations and height conditions

Section 3: Floor Heights; Protrusions; Enclosed/Exposed Balconies; Staircases

Section 4: Enclosure of construction sites and public properties

Section 5: Particular regulations to the different urban areas and building types

5.1 Individual palaces

5.2 New Residential Areas

5.3 Older neighborhood areas – residences inside the city wall

5.4 Light industries area

5.5 heavy industries area

Section 6: Sanitary Regulations (plumbing and drainage)

Section 7: Miscellaneous Provisions

Section 8: Final Provisions

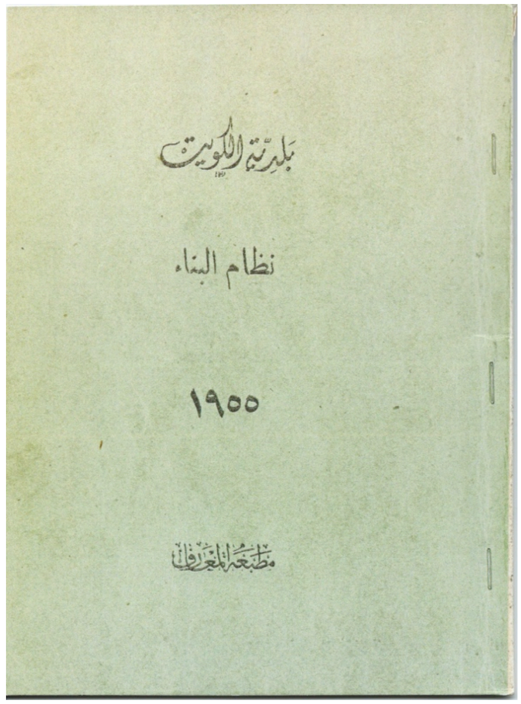

Figure 1. The Building Code of 1955, published by Kuwait Municipality

The enactment of the 1955 building code was evident in the report of Saba Shiber (the Architectural and City Planning Advisor to the government in the 1960's) addressed to the Municipal Council in 1961. It states:

> The draft for a new building code has been prepared for the city of Kuwait that incorporates many sound principles of building practice. It is expected that, soon, the Municipal Council will enact this essential piece of legislation into law. Regulations governing coverage of land, heights, and setbacks in residential areas have already been enacted into law. (p.17)

As Shiber indicates, several sets of building regulations then followed that of 1955. A set of building regulations was issued in 1961 and within three years - in his documentation of his experience in Kuwait's urbanization process (1964) - Shiber mourns the separation of "indigenous and local characteristics and problems" from "the overall picture". The absence of culture and place became apparent in the urban environment as a product to rapid imported transformation. He further explains with distress:

> There is Kuwait's climate and local building materials; there is the existing and particular urban fabric and social structure; there is the existing and particular urban fabric and social structure; there is the particular and unique economy and the demographic dynamics; there are the cultural-ethnic characteristics and the landscape features that must enter the picture in the synthesis and evolution of a housing program, in building it, managing it, and making it a human environment instead of merely a dormitory assemblage of monotonous and soulless buildings. (1964, p. 228)

The 1961 Building Code was later followed with another issuance in 1979, and another in 1985, which largely included all the provisions and rules that are still in effect today. The 1985 building regulation controlled development practices of all the allowable building types and densities of land use. Through different modifications since 1985, the document has quadrupled in size, with its sections almost doubled and renamed as "Schedules". The latest amendment in 2008 contained:

Schedule 1 Conditions and Specifications of Typical Units and Private Residences Under the Municipal Council Decision No. 2008/5/71/7, Dated 7/4/2008

1st Typical Units and Private Residences

Article 1: Floor Area Ratio "FAR"

Article 2: Building Setbacks and Adjoining

Article 3: Building Heights

Article 4: Distribution of Areas

Article 5: Stairways

Article 6: Projections

Article 7: Shafts

Article 8: Shades/Pergolas

Article 9: Annexes Separate from Main Building

Article 10: Basement

Article 11: Building Services

2nd Private Residential Houses Adjacent on the Same Plot

3rd Diplomatic Area – West Mushrif

4th Multipurpose Halls

Schedule 2* Conditions and Specifications of Investment Residential Buildings (outside and inside Kuwait City) under the Municipal Council Decision No. 2008/7/172/, Dated 5/5/2008

Schedule 3* Conditions and Specifications of Commercial Buildings (outside and inside Kuwait City) under the Municipal Decision No. / /2008, Dated / /2008

* Schedule specific articles were not included for the purpose of this study

Schedule 4* Conditions and Specifications of Buildings in the Industrial Areas under the Municipal Council Decision No. 2008/5/74/6, Dated 7/4/2008

Schedule 5* Conditions and Specifications of Residential Complexes (outside and inside Kuwait City) under the Municipal Council Decision No. 2008/7/172, Dated 5/5/2008

Schedule 6* Conditions and Specifications of Commercial Complexes (outside and inside Kuwait City) under the Municipal Council Decision No. 2008/7/172, Dated 5/5/2008

Schedule 7* Conditions and Specifications of Buildings at the Coastal Strip Area under the Municipal Council Decision No. 2008/5/77/6, Dated 7/4/2008

Schedule 8* Conditions and Specifications of the Green Houses in all Areas of Kuwait under the Municipal Council Decision No. 2008/7/172/, Dated 5/5/2008

Schedule 9* Conditions and Specifications of Chalet Buildings in all Areas of Kuwait under the Municipal Council Decision No. 2008/7/172/, Dated 5/5/2008

Schedule 10* Conditions and Specifications of Private Hospital Buildings in

* Schedule specific articles were not included for the purpose of this study

all Areas of Kuwait under the Municipal Council Decision No. 2008/7/172/, Dated 5/5/2008

Schedule 11* Conditions and Specifications of Private School Buildings in all Areas of Kuwait under the Municipal Council Decision No. 2008/10/242/, Dated 23/6/2008

Schedule 12* Conditions and Specifications of Hotel and Motel Buildings in all Areas of Kuwait under the Municipal Council Decision No. 2008/7/172/, Dated 5/5/2008

Schedule 13* Conditions and Specifications of Agricultural and Animal Raising Areas under the Municipal Council Decision No. 2008/7/172/, Dated 5/5/2008

Schedule 14* Conditions and Specifications of Non-Profit Organization Buildings at Jleeb AlShuyoukh under the Municipal Council Decision No. 2008/7/172/, Dated 5/5/2008

Since its issuance, the Building Code went through several modifications, which Mahgoub (2002) has surveyed to find its development trends and unfavorable impacts. His study examined the incessant changes of the regulations and its impacts at the single-family residential neighborhood level. Mahgoub, using observation analysis as a tool, specifically observed the impacts of changed setback

* Schedule specific articles were not included for the purpose of this study

and allowable area regulation on the configuration of the built environment. These included hostile streetscape, invasion of privacy, lack of character, loss of green-space, reduction of suppressed social interaction, historical discontinuity and visual pollution. Undoubtedly, building regulations constitute a major contributing factor in determining the urban environment. Kuwait is a radical case, with the building regulations heavily concerned with land-use and negatively intensified by its divorce from context. The current and effective code regulating the urban landscape of Kuwait urgently calls for further examination of its impact on the physical environment and urban quality.

2.2.2 ***The Arrival of the Neighborhood Unit*.** Section 2.2.1 reviewed the processes undertaken in Kuwait since the arrival of oil to identify the rapid transition of urban form through comprehensive master planning, which as a result became an institutionalized approach. The first master plan - commissioned to MSM in 1951 and implemented that same year –, as Abdo states, "left a permanent impact on the State's physical development", the elements of which he summarized as:

> a. As reference points, the Development consisted of radial roads converging on and providing access to the old town as extended through its wall gates, and concentric roads running parallel to the line of the town wall, with the first of several ring roads forming along the southern limits (wall) of the town.
>
> b. The resulting pattern outside the town was the formation of over twenty 'super-blocks', surrounded by the road network. These blocks were for the most part residential neighborhoods measuring about two sq.km (Figure 2), with each containing its own social and civic facilities such as super-market cooperative, shops, clinic, mosque,

post office in a central are, in addition to a number of schools located in more than one location. The remainder of the super blocks were designated for industrial, education and health uses.

c. The semicircular line representing the old town wall (of which only the gates were to be left standing) with a width of about 250 meters, was reserved as a recreational strip which came to be known as the 'Green Belt'.

d. As for the old town itself, the plan basically provided for the widening of its main roads rather than creating a different circulation pattern, with zoning for various types of land use.

e. The old town was targeted for large-scale re-development as the focal point of business and government for the expanded city – 'Greater Kuwait' – with only limited use as a residential area. (Abdo, 1988, p. 115)

Figure 2. **Left**. Old walled town of Kuwait (Pre-Oil Era) **Middle.** Kuwait's first Master Plan, commissioned to MSM, with the concept of dramatically extending the city beyond its walls in a radial structure with the use of the ring roads **Right.** Highlighted is the pattern resulting outside of the town (the neighborhood units) in a nonnative central structure as opposed to the local linear structure.

Illustration by author based on: Kuwait Oil Company (1951) and Minoprio & Spencely and P.W. Macfarlane (1951)

The resulting pattern outside the town is the focus of this section, especially the identical neighborhoods or the ‘super-blocks’. As mentioned above, and methodically explained by Abdo, the radial roads and the ring roads extending outside the town influenced the future pattern of urbanization and by and large shaped the approaching eight “neighborhood-units”. Shiber (1964) claims that Kuwait was the first Arab city that adopted the neighborhood-unit concept in its comprehensive planning.

The neighborhood-unit concept was developed and clearly articulated by Clarence Perry in the 1920s in the United States (Levy, 2013; Patricios, 2002). The basic idea underlying the neighborhood unit concept is to encompass: “(1) a limited population; (2) the essential supporting neighborhood facilities and the amenities for this population such as shopping facilities, kindergarten and primary schools, a clinic and a place of worship; (3) traffic separation; (4) adequate park, recreation and sports facilities; (5) around five to six neighborhood units constituting a ‘community’ with community facilities and amenities such as high schools, auditoria, adequate shopping and recreation facilities and so on“ (Shiber, 1964, p. 219). In the case of Kuwait, and within three years of the master plan, Macfarlane explains the “neighborhood units” in the *Journal of the Town Planning Institute* as the following:

> Outside the wall, the land planned for development will accommodate some 48,000 persons and covers an area greater than the old town inside the wall. Almost flat and all sand, it is being divided by main roads into eight communities of approximately 6,000 persons. Each will have its mosque, public hall, shops, site for service industry and separate primary schools for boys and girls with ample room for play and games, as well as six nursery schools. Every four neighborhoods

> will be served by two secondary schools. Several schools are under construction and the first neighborhood area is at present being laid out.
>
> Within the neighborhoods, internal development roads are laid out roughly on an east-west line and each serves normally about 160 houses grouped round a nursery school. House plots, varying in size from 500 sq. meters to 1,000 sq. meters, and 50% built over. (Macfarlane, 1954, p. 113)

Although Perry's development of the neighborhood unit came as a product resulting from dissatisfaction with zoning – 30 years prior to the MSM master plan of Kuwait – preposterously it was still incorporated and ingrained in the practice of Minoprio & Spencely and P.W. Macfarlane's town planning. Paradoxically, as Talen (2009) puts it, "[C]larence Perry lambasted zoning as inflexible and not able to invest a residential district with 'attractiveness'" (p.155), but ironically his product was developed by the consultants to be fused as a zoning function at the outset of planning Kuwait.

In an analytical critique of this imposition and forced non-native concepts, Sabbar (1971) explains how MSM's neighborhood arrangement is incompatible with Kuwait's social and cultural context. He explains that the neighborhood centers in their Western style of occupying physical central sites are highly challenging of local social norms. Sabbar argues that the "European notion of sitting centers and services in the middle of a green open space, and the wife walking her child to school and then strolling to the supermarket for her shopping needs, is not the norm in Kuwait"

(1971, p. 72). He suggests that a better configuration would be to arrange the house plots with the neighborhood amenities along a longitudinal corridor, as it was traditionally. The principles of the traditional setting (further explained in its regional context in section 2.1.2) allow for qualities that promote cohesiveness in honest urban forms that respond to local requirements. Shiber explains his dissatisfaction resulting from the discordance and disharmony of the city due to the applied and unsuitable Western developed concepts, as he states:

> Contrasting with the simple, humble, dignified, beautiful and organic architecture that is the heritage of the Old Kuwait is the complicated, gaudy, undisciplined, ill-mannered and inorganic architecture that has in "one fell swoop," replaced or bulldozed away the tranquil and indigenous architecture deriving from the Kuwait habitat […] Any discussion of housing is incomplete without reference to the absence, so far, of a balanced, harmonious and varied admixture of different known types of housing. Strange physical-architectural phenomena characterize the present residential areas of Kuwait. The neighborhood units contain, one hundred percent, the single-house type of residential areas of Kuwait. The remaining areas, particularly those in the Hawalli-Nugra-Salmyya residential areas, contain the multifamily type dwelling going up in height sometimes to four stories. This dichotomous segregation of housing type may have had some strong justifications in the past. However, it would seem inadvisable to continue designing neighborhood-units on the basis of only the single house type at the expense of the exclusion of all the other types, as well as allowing buildings to create radical dichotomies in overall residential zoning or distribution. (Shiber, 1964, pp. 287, 231)

The many scholarly questions and critiques of the replacement of the rational old by the irrational new urbanization principles, environments and architecture of the post oil era in Kuwait are still valid and applicable to the contemporary situation. Development practices are still considered ill-suited to the climate and to the remaining traditions, which calls for a need to guide and govern practices to develop truthful domestic urbanism and further enhance urban quality in Kuwait City.

Chapter 3

Simulation Framework

3.1 Site Selection

To empirically test and evaluate the current impacts of building regulations on the performance of urban form, a residential area was selected. That is mainly because the major part of Kuwait's urban area is devoted to dwelling units, which by and large fall in two distinct types of dwellings: single family (low density) or multifamily (high density) units. The Central Statistical Bureau of Kuwait has conducted a Building and Dwelling Census (2011) displaying the number of buildings by type in each governorate as shown in Table 1. It can be clearly depicted that single dwelling units dominate the current physical fabric of Kuwait, accounting for 71%, the highest of all building type categories.

Table 1.
Building and Dwelling Census (2011) conducted by the Central Statistical Bureau of Kuwait

Building Type	Al-Asimah	Hawalli	Al--Ahmadi	Al-Jahra	Al-Farwaniya	Mubarak Al-Kabeer	All Governorates
Apartment (Multifamily)	907	6,945	2,580	518	3,933	382	**15,265**
Villa (Single Detached)	16,958	20,392	21,384	12,334	18,306	18,029	**107,403**
Palace (Single Detached)	46	35	10	6	3	11	**111**
Vernacular Dwelling	2,310	271	2,485	12,186	4,590	552	**22,394**
Chalet	221	10	2,097	170	30	16	**2,544**
Other Vernacular Buildings	788	121	2,927	6,331	2,651	117	**12,935**
Shanty	174	60	103	375	79	45	**836**
Other Auxiliary Buildings	331	409	544	2,108	604	101	**4,097**
Hotel and Apartments Hotel	45	69	36	31	33	9	**223**
Retail Complex	1,137	253	275	291	571	217	**2,744**
School	136	201	195	148	173	95	**948**
Hospital	36	25	24	12	17	11	**125**
Clinic	23	11	14	17	22	8	**95**
Police Station	14	9	12	17	11	6	**69**
Grocery Store	120	114	133	148	120	70	**705**
Mosque	238	176	284	219	249	116	**1,282**
Religious Building	6	4	7	7	5	1	**30**
Restaurant	129	69	33	38	40	17	**326**
Sports Club	39	26	23	13	13	12	**126**
Governmental Building	431	277	399	372	214	110	**1,803**
College	19	11	7	-	10	1	**48**
Institute	23	29	9	1	6	4	**72**
Sports Complex	10	17	4	5	5	3	**44**
Embassy	53	42	2	-	-	-	**97**
Banks and Branches	61	29	33	15	37	17	**192**
Factory	28	7	214	380	84	316	**1,029**
Under construction	2,142	733	915	1,952	1,121	275	**7,138**
Total	**26,425**	**30,345**	**34,749**	**37,694**	**32,927**	**20,541**	**182,681**

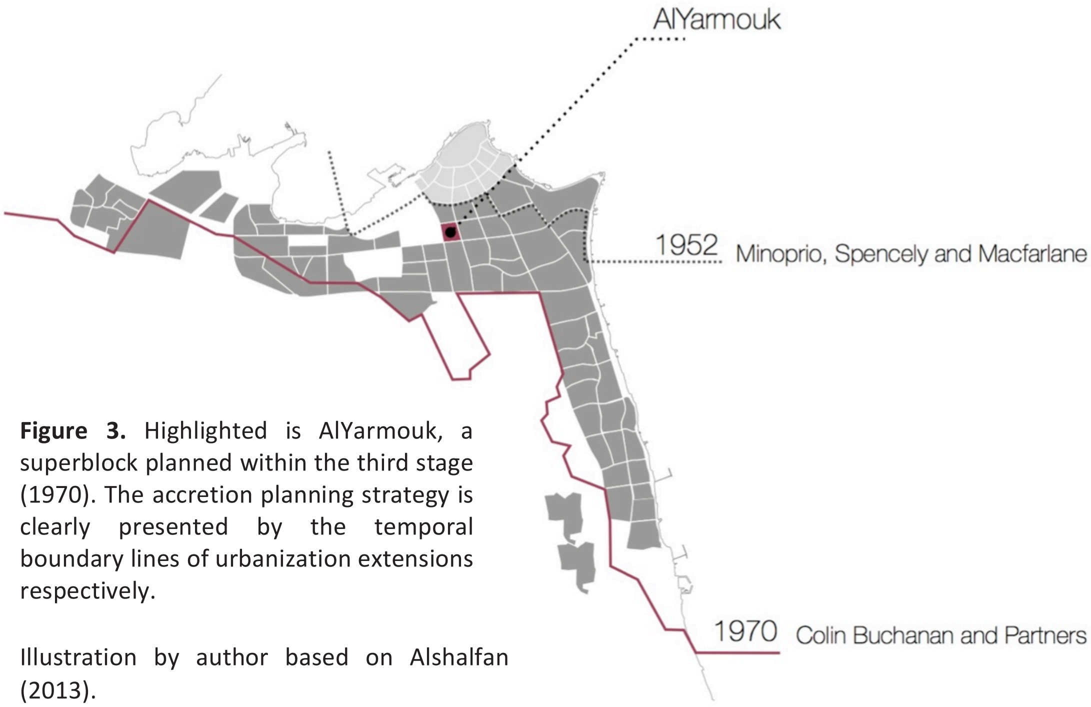

Figure 3. Highlighted is AlYarmouk, a superblock planned within the third stage (1970). The accretion planning strategy is clearly presented by the temporal boundary lines of urbanization extensions respectively.

Illustration by author based on Alshalfan (2013).

AlYarmouk, the selected residential area, was selected because it typifies the accretion planning strategy in the execution of the master plan and its building codes. With its high number of parcels devoted only to single dwelling units, AlYarmouk represents the larger context of the applied neighborhood unit concept and its resulting array of unintended consequences.

The area is a 'super block' planned within the third master plan of Kuwait by Colin Buchanan and Partners (1970) and executed during a 10-year period [Figure 3]. According to Collin Buchanan and Partners, during the planning of AlYarmouk and the latter neighborhoods the "original 'super-block' system of development was extended" (1970, p. 4). The distribution and platting of the neighborhoods were planned "broadly on the lines of the first neighborhoods (Dasma, Shaab, Kaifan, Faiha) namely at low density, with wide internal roads and generous incidental open space, with a centrally-located neighborhood center … and a number of 'local centers' – (approximately one every 300 plots)" (Collin Buchanan and Partners, 1970, p. 32). Typically, the distribution of land uses within the planned residential areas include the dwelling units, a central cooperative supermarket and retail plaza, a health clinic, police station, public school, mosque, playing field, roads and parking. AlYarmouk inhabits 1,336 parcels that range from an approximate area of 375 to 1,000 square meters organized in 4 blocks of approximately 334 units each and the central block for public services and supporting amenities. Figure 4 shows the geometric structure of Block 1 that generally represents larger context of the applied 'neighborhood unit' concept and is considered an appropriate sample to this investigation.

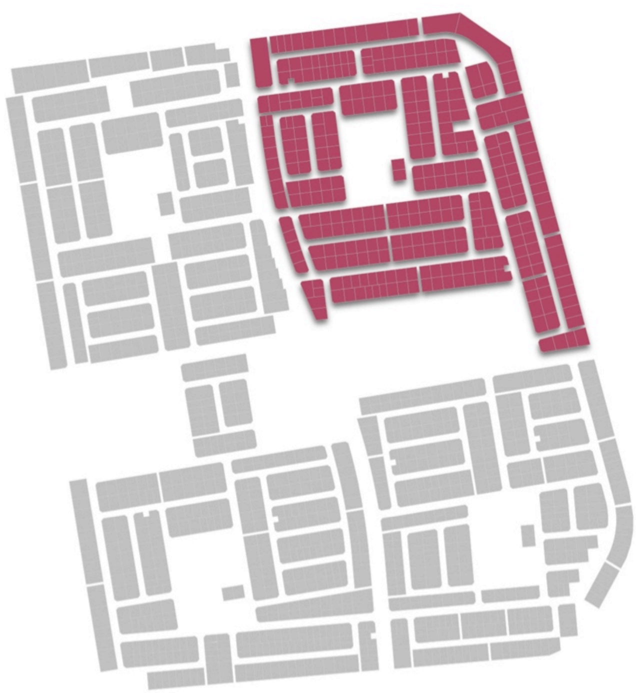

Figure 4. AlYarmouk's 'superblock' structure organized into four neighborhood units, each with a central services area. Highlighted is the selected Block1.

3.2 Simplification Process

To perform such an investigation, the process of classification and simplification of the existing urban environment's complexity becomes essential. Such a process was pioneered by March and Martin (1972) whose simplified urban arrays on the basis of archetypes were analyzed, influencing numerous urban inquiry approaches. While looking at the impacts of urban governance, defined for the purpose of this research as the Kuwaiti Building Code, the method begins with **(a)** the translation of the ruling text into its numeric-spatial parameters, **(b)** the development of parcelization schemes (simplification), **(c)** the classification of building archetypes, and **(d)** the definition of building properties into templates, a process further explained in the following sections.

3.2.1 ***KBC Parameters.*** As mentioned earlier in Section 2.2, the relevant area to be examined within the Kuwaiti Building Code is "*Schedule 1. Conditions and Specifications of Typical Units and Private Residences*" (Municipal Council Decision No. 2008/5/71/7, Dated 7/4/2008). From the previously listed eleven articles of Schedule 1, three sections are associated with the spatial parameters of urban forms produced by the KBC. These are the allowable *Floor Area Ratio* (FAR), the minimum *Building Setback* (side and front), working in concert with the maximum *Building Height* to influence building form. While the rest of the eight articles influence the products of urban form, the former significantly outweighs them. Listed in Table 2 are the allowable urban form parameters as regulated within the KBC and later used in the development of the Building Archetypes (further explained in section 3.2.3).

Table 2.
KBC allowable building form spatial parameters

Parcel Area (sqm)	**FAR**	**Setback**		**Height** (m)
		Front* (m)	Side (m)	
250-349	800 sqm	2	1.5	• 3 (min floor to floor)
350-400	210% + 120 sqm	2	1.5	
401-749	210%	2	1.5	• 15 (max building height)
750-	210%	3	2	

* building on front parcel boundary line is allowed for the ground floor only with a maximum of 50% linear frontage

3.2.2 ***Parcelization Schemes*.** Determining the size of parcels in planning Kuwait's residential urban areas was strongly influenced by the first master plan of Macfarlane, et al., in 1951. In the development of the third master plan, Buchanan proclaims the process of using the then existing (1970) density figures from five single dwelling residential areas (Mansouriyah, Idailiya East, Shamiyah, Qadisiyah and Khalidiya) as a guide (Collin Buchanan and Partners, 1970). This resulted in an accretion-planning strategy of neighborhoods with a combination of 750 and 1,000 square meter parcels, as is the case with AlYarmouk and the rest of the planned neighborhood units. Such an influence, which still predominates throughout current practices, is the governing principal of the simplification process deployed in this study. The development of the parcelization schemes came in two stages; the generic parcel dimensions and the neighborhood configuration. To incorporate the largest possible parcel types in this investigation, four generic parcel dimensions were considered (Figure 5).

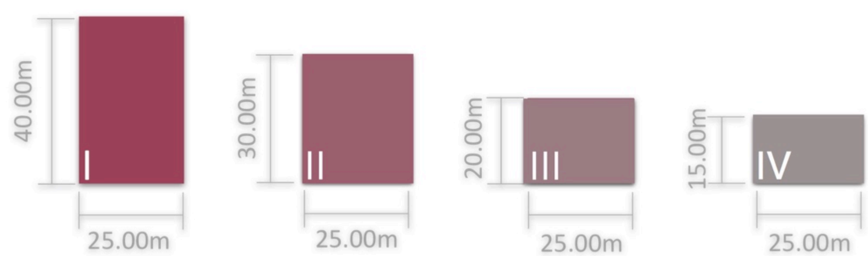

Figure 5. Four generic parceltypes (PT): (PT1) 1000 sqm, (PT2) 750 sqm, (PT3) 500 sqm and (PT4) 375 sqm.

The selected neighborhood unit, Block 1, was then simplified by regularizing its physical form while maintaining its spatial extents (Figure 6). Reverse platting was later performed where adjacent parcels were consolidated outlining a periphery line to allow the ordering of PT1 and PT2 in a scheme and PT3 and PT4 in another. This resulted in two distinct parcelization schemes, one including the original 1,000 (PT1) and 750 (PT2) square meter parcels, and the other being a second generation of attempted densification using 500 (PT3) and 375 (PT4) square meter parcels – a practice of dividing the original parcel types to increase density. Both schemes have the parcels arranged within the peripheral limits derived from the reverse platting process of the original block (Figure 7).

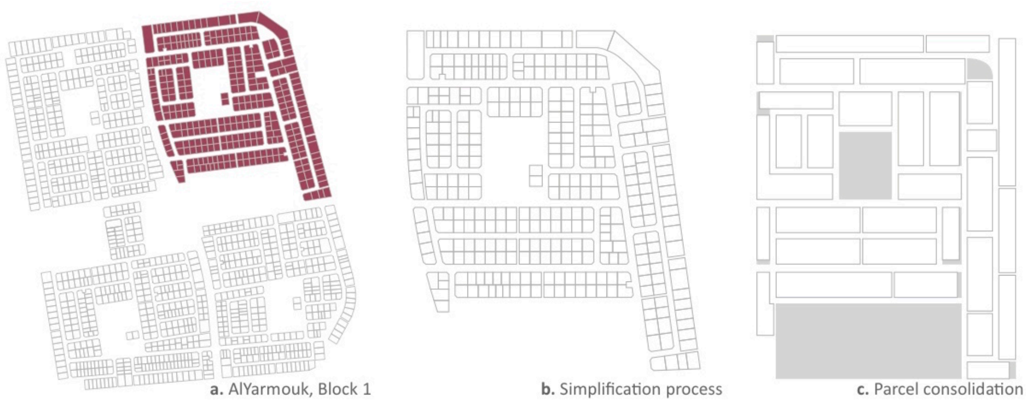

Figure 6. AlYarmouk Block 1 simplification process.

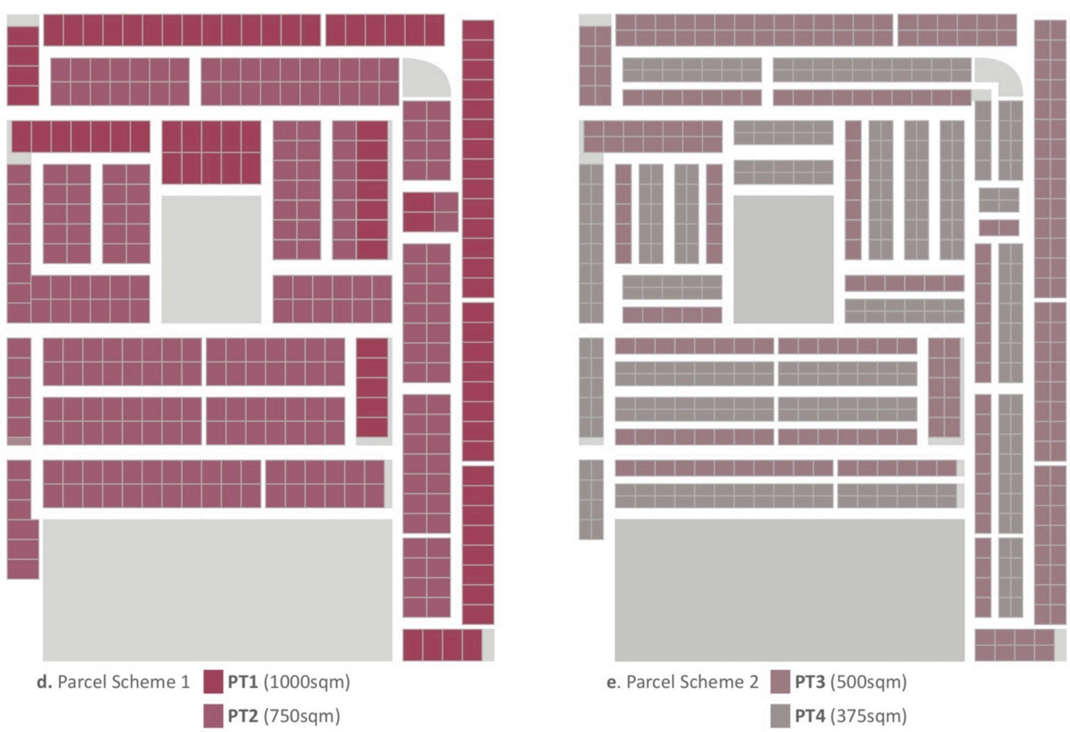

Figure 7. The resulting two parcelization schemes and the configuration of the four parcel types. Parcel Scheme 1 includes a combination of PT1 and PT2, where Parcel Scheme 2 includes PT2 and PT3.

3.2.3 ***Building Archetypes and the Urban Arrays.*** To represent the range of present built forms within the residential context of Kuwait, four distinct building typologies were classified. Figure 8 illustrates the generic typologies in the context of filled against void volumes within any of the four parcel-types. The four building typology classifications are: *centered* to the plot boundaries, *reared* from the parcel's frontage, enclosing a *central-void* and lastly the *edge-voided*.

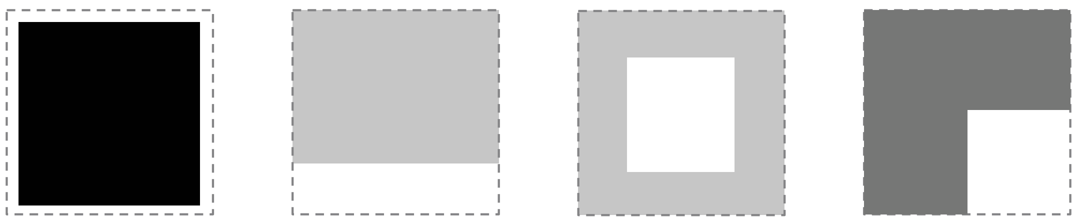

Figure 8. Four generic building typologies the *Centered*, *Reared*, *Central-Void*, and *Edge-Void*.

Assigning each of the typologies to the four parcel types and conforming their massing to the allowable parameters of the KBC developed sixteen discrete archetypes. This approach is to be considered a simplified representation of the existing urban forms produced as a result of the KBC. All of the archetypes are within 100% compliancy with KBC Schedule 1 (see Section 2.2 and 3.2.1), window-to-wall ratios were applied uniformly and determined by orientation, and other non-geometric properties were equivalently assigned to all archetypes as discussed further in Section 3.2.4. This is in an effort to keep all spatial and non-spatial building properties analogous and restrict the distinction to only the physical layout of the archetypes. The investigated sixteen archetypes are illustrated in Figure 9 and vary horizontally by generic typology and vertically by parcel type.

Using the simplified site layout of AlYarmouk Block 1 (Parcelization Schemes 1 and 2), eight theoretical urban arrays were developed by extrapolating the archetypes to their corresponding parcels (Figure 10).

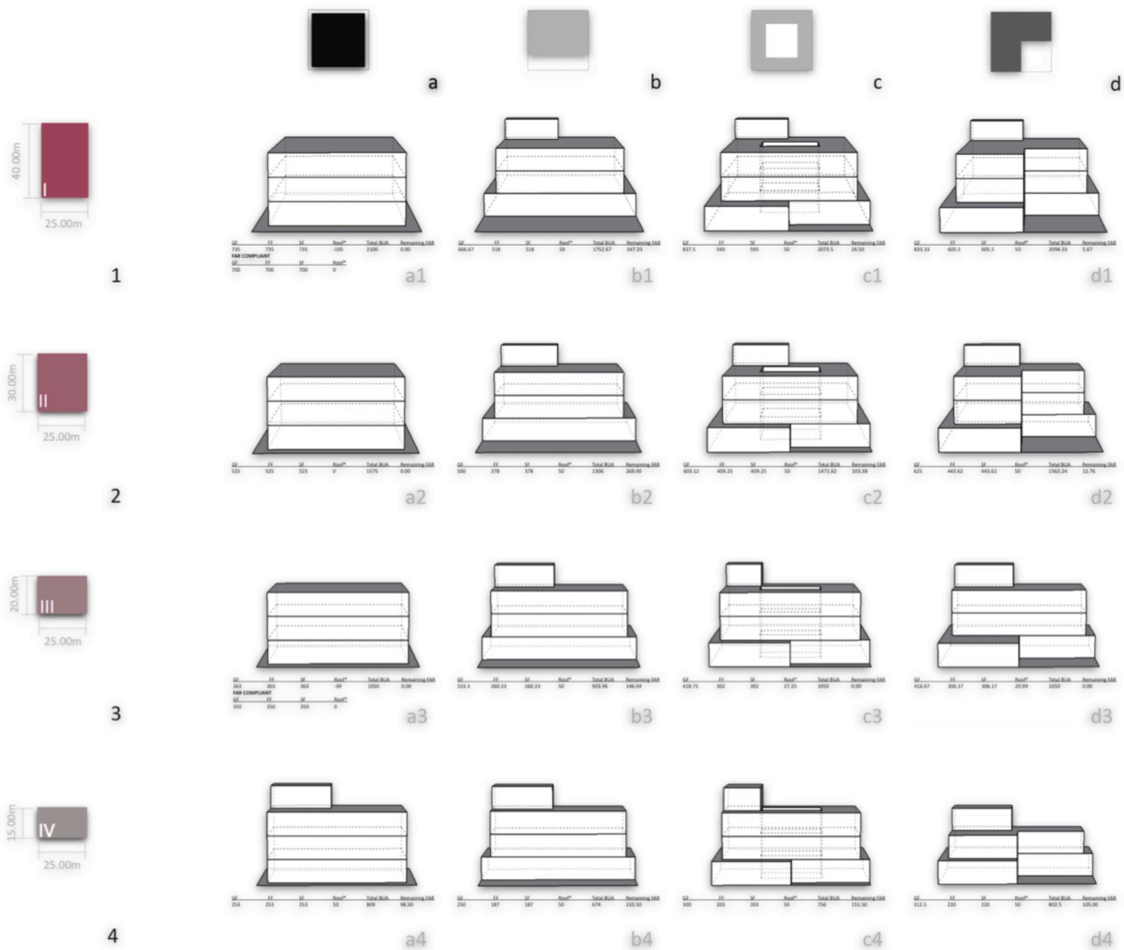

Figure 9. The sixteen developed archetypes and their spatial compliancy to the maximum allowable FAR, setbacks, minimum floor-to-floor heights and maximum building heights.

3.2.4 ***Building Property Template*** (BPT). Translating building properties into templates is a process of inputting non-geometric data into the Template Library Editor (an independent application provided with UMI). The data is necessary to execute building performance simulation and include thermal loads (occupancy, equipment, lighting and infiltration), construction assembly properties and conditioning systems (set points, rates and CoP of the systems). Such data was mainly retrieved from available documentation found in energy and construction regulatory codes, published research (Al-Mumin, Khattab, & Sridgar, 2003) and local expertise. It was also assumed that all buildings are to be newly constructed and conforming with the latest modification of the Ministry of Energy and Water's Energy Conservation Code (MEW, 2014). That said, and as mentioned earlier, one BPT was developed and assigned to all the archetypes to restrict any dissimilarity to only their physical and spatial properties.

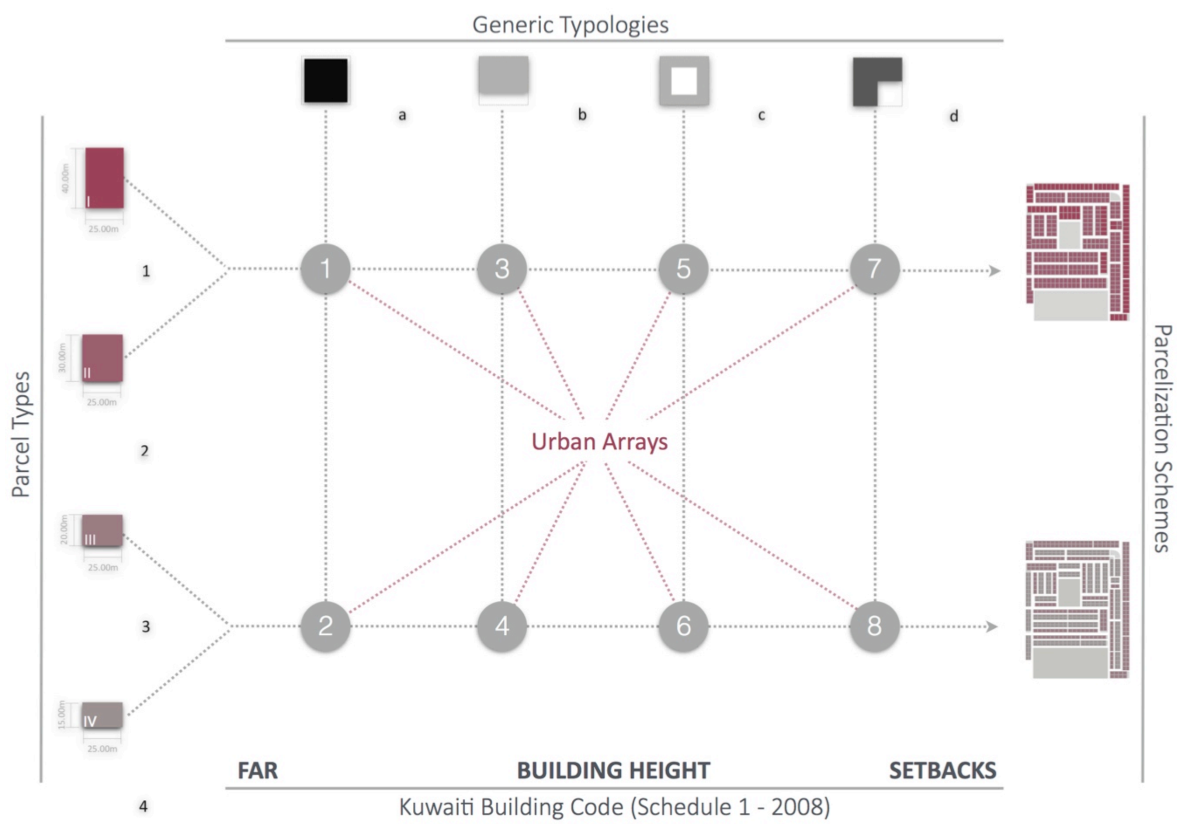

Figure 10. The eight theoretical urban arrays that include all the sixteen archetypes arranged as per parcelization scheme 1 and 2.

CHAPTER 4

Performance Metrics & Findings

Evaluating the performance of the theoretical neighborhoods was modeled in an experimental workflow between two software platforms (1) UMI and (2) ENVI-met. The deployed plug-in tool for the Rhinoceros3d CAD modeler, UMI, allows for modeling the environmental performance of neighborhoods with respect to operational energy, embodied energy (lifecycle impact) and design accessibility (Reinhart et al., 2013). On the other hand, ENVI-met, the climate model, has a high spatial and temporal resolution that enables a study of microclimate variations within the neighborhoods as a result of the different typologies (Bruse, 2004). The pertinent performance metrics as evaluated by the available scholarship (Section 2.1.3) and selected for the purpose of this research are: (**1**) land-use utilization by measuring floor-area-ratio of the eight theoretical urban arrays, (**2**) operational energy of each of the sixteen archetypes within the theoretical neighborhood configurations, (**3**) accessibility through a walkscore evaluation of the two parcelization schemes, and (**4**) outdoor thermal comfort.

4.1 Floor Area Ratio

Urban density is a highly disputed term in the discourse of urbanism, with debates that range from counterarguments in defining and relating its resulting urban forms to urban quality and performance. Measures of urban density have "evolved form being a result of circumstances to a practically applied, normative concept in city development" (Pont & Haupt, 2010, p. 18) and are considered as a very relatively conceived urban metric. Despite this confusion, a FAR, or Floor Area Ratio, calculation is measured to realize the land utilization of the eight different urban arrays without any reflection of their spatial properties. That is to empirically assess current practices with the intentions of densification through the division of parcel types 1 and 2 to all of the four generic typologies. The resulting FAR metrics have been mapped into Table 3. Supporting the debate on density as a metric, the findings illustrate how Parcelization Scheme 2, regardless of the building typology, paradoxically seems to have the lowest FAR. This means that the densification intentions are flawed when considering land-use efficiency, another measure that should come in tandem with the rational of densification. Although this requires further investigation, at this point such findings could be directly correlated to the KBC parameters when applying the setback requirements and the allowable FAR to the second-generation parceltypes, namely PT3 and PT4.

Archetype	Urban Array	Parceltype	BUA/Building	Building Count	Total BUA	FAR
CENTERED	1	1	2100	92	193200	1.19
		2	1575	255	401625	
				Total BUA	**594,825**	
	2	3	1050	256	268800	1.04
		4	809	314	254026	
				Total BUA	**522,826**	
EDGE VOID	7	1	2094.33	92	192678.36	1.18
		2	1562.24	255	398371.2	
				Total BUA	**591,050**	
	8	3	1050	256	268800	1.04
		4	802.5	314	251985	
				Total BUA	**520,785**	
CENTRAL VOID	5	1	2073.5	92	190762	1.13
		2	1471.62	255	375263.1	
				Total BUA	**566,025**	
	6	3	1050	256	268800	1.01
		4	756	314	237384	
				Total BUA	**506,184**	
REARED	3	1	1752.67	92	161245.64	0.99
		2	1306	255	333030	
				Total BUA	**494,276**	
	4	3	903.96	256	231413.76	0.88
		4	674	314	211636	
				Total BUA	**443,050**	

Table 3. Floor Area Ratio of the developed building typologies on of the eight urban arrays based on the four generic archetypes and the two parcelization schemes.

4.2 **Operational Energy**

Very much related to the sense of enclosure is the direct relation of building heights and street-width ratios to controlling solar gains and access to daylight. In the evaluation of built form compared to operational energy in a cooling dominated climate such as Kuwait, these two central measures compete. Access to daylight is directly proportional to solar gains, of which the latter is ideally not favored in this case. Street width strongly determines the amount of direct radiation received on the lower floors of the buildings with respect to the impact of orientation on the time of the day when radiation is received. The different archetypes and their configurations within the eight theoretical urban arrays are evaluated in terms of their operational energy. A section of the parcelization scheme that best represents the neighborhood unit was chosen for the simulation as illustrated in Figure 11 to best represent each urban array by including the two parceltypes respectively. This selection will allow a simulation performed on all the four resulting archetypes of each typology.

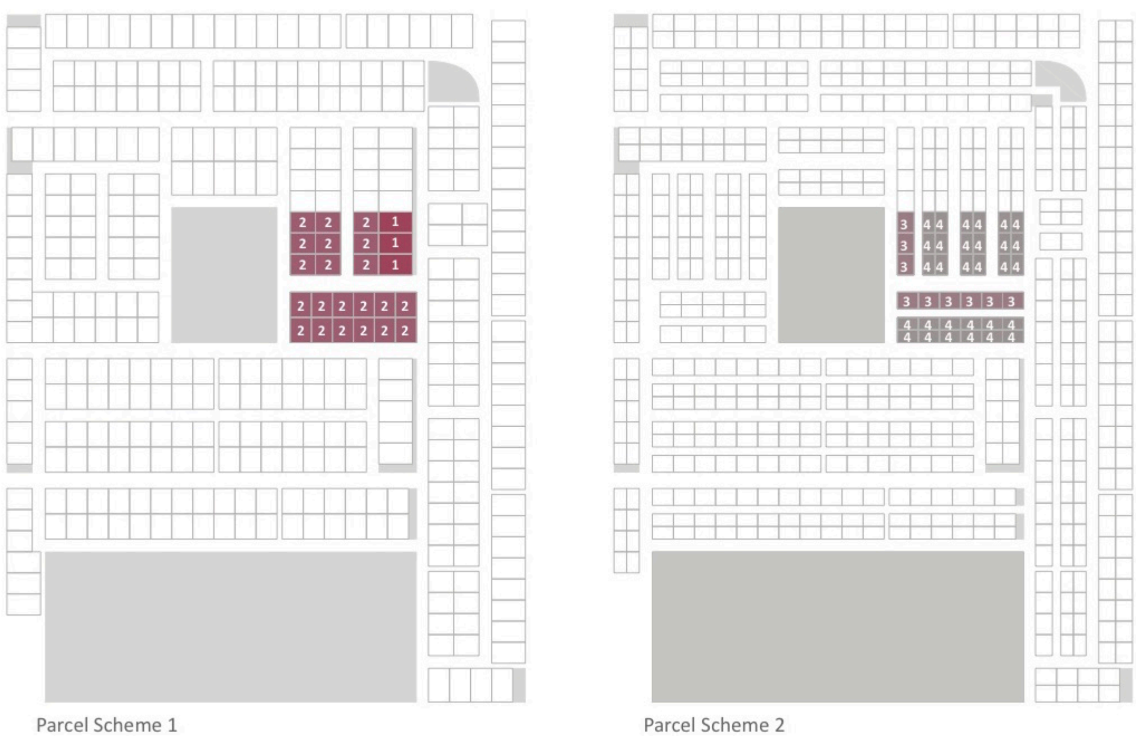

Figure 11. The selection within the two parcelization schemes evaluated for operational energy performance. Each parcel (total of 63 in the two schemes) represents an archetype of the original generic typology. A total of 252 simulation runs were performed.

Figure 12 shows the simulated yearly operational energy performance for each of the selected parcels using the four typologies. The simulation overlooks the aspect of spatial quality by assuming that less daylight will cause less solar gain and hence a better performing archetype. It is also not considering passive systems, only accounting for active systems representing the universal dependence on air conditioning systems, artificial lighting, and electrical appliances among households in Kuwait (Jaffar, Oreszczyn, & Raslan, 2014). A fixed occupancy density assumption was set to all archetypes as well, through the building property template. As presented in Figure 12, the centered typology archetype outperforms the rest, supporting the long-standing suggestion of research, of applying deep-form building typologies in hot-arid climates (Olgyay, 1963). The least performing typology would be the central-void, which also brings up the question of energy efficiency and thermal comfort of central courtyard buildings. It can be also shown that larger parceltypes outperform smaller ones, as illustrated from left to right, which also supports the employment of deeper urban forms in hot-arid climates. The average annual electrical consumption of each building parceltype with the four archetypes is illustrated in Figure 13.

These findings suggest the need for further investigation to develop a set of architectural design elements as additional features to enhance the performance of each typology. It also implies a need for testing the impact of hybrid behavioral patterns in the use of passive and active systems. Ultimately the exercise should result in an index of architectural elements to be added to the original typologies in certain circumstances as well as passive/active behavioral patterns to enhance their efficiency.

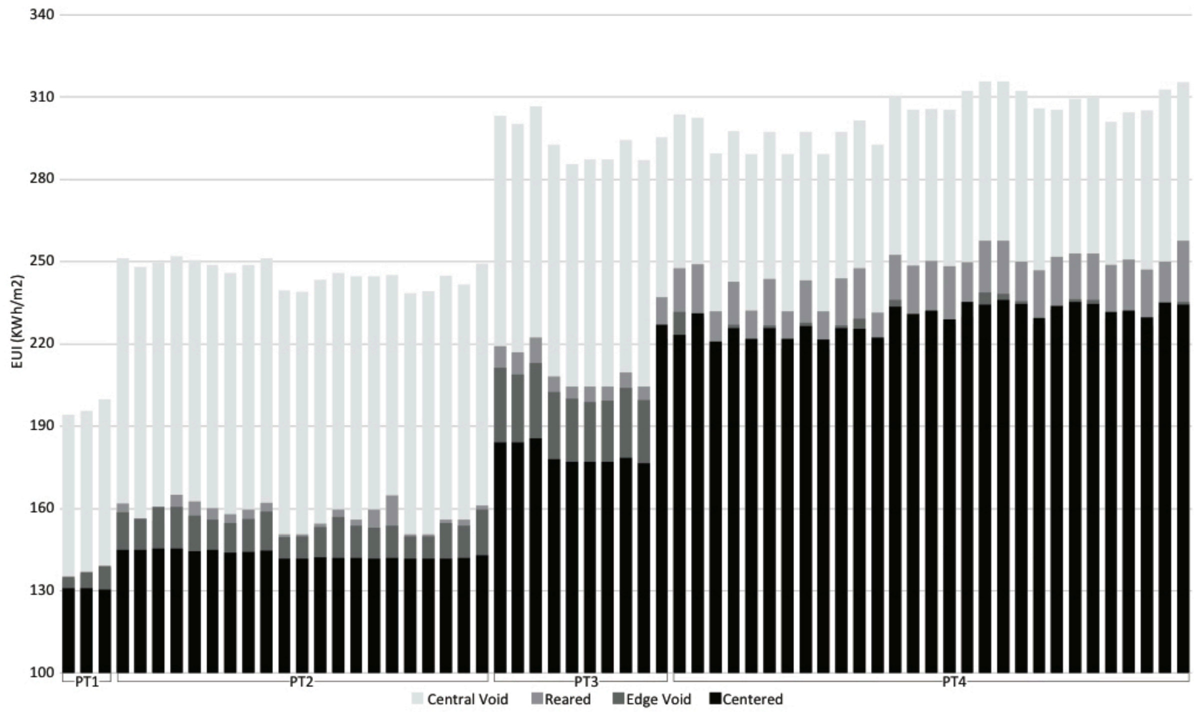

Figure 12. Simulated annual operational energy of the four archetypes.

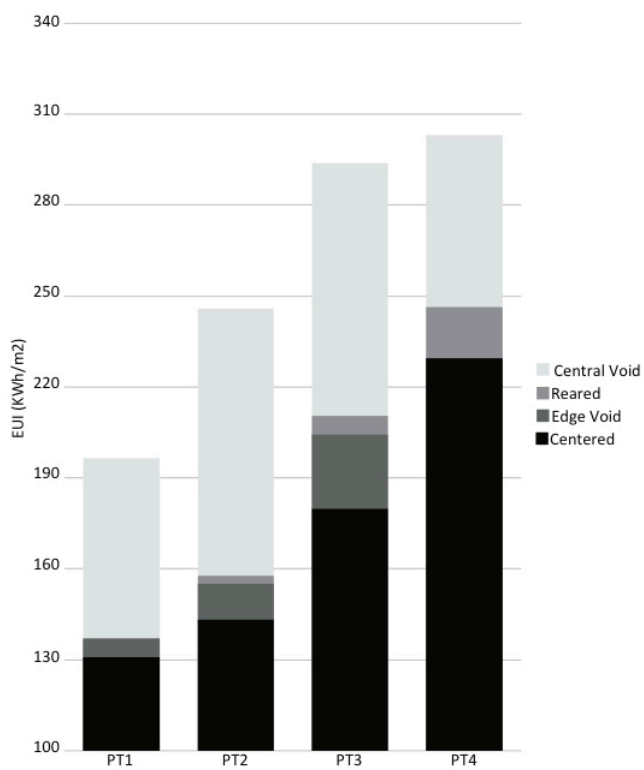

Figure 13. Average simulated annual operational energy of the four archetypes per parceltype.

4.3 Accessibility

The design and certainly the spatial configuration of any neighborhood will encourage or discourage particular modes of transportation, namely walkability and bikeability. Using the Street Smart Walk Score algorithm developed by Walkscore®, UMI calculates the Walkscore values of each building based on the defined distances and amenity categories within the assigned amenity templates. For the purpose of this investigation, walkability is used as a metric to evaluate the urban formation of a typical Kuwaiti neighborhood that has been structured through non-native standards and codes.

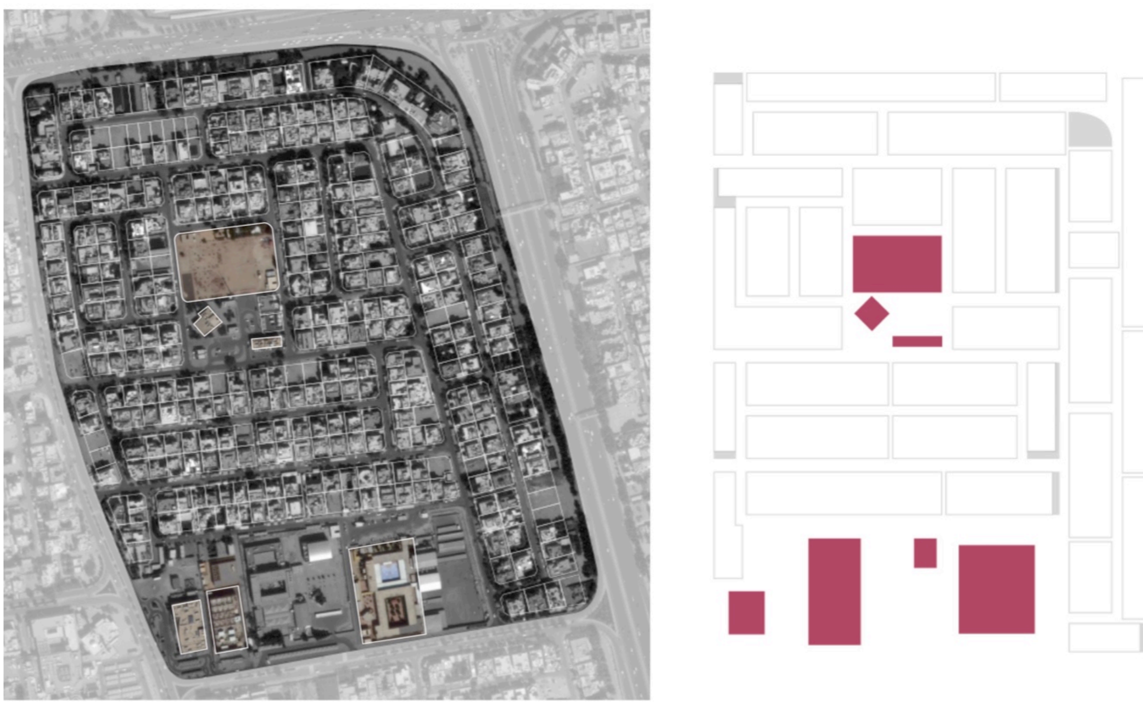

Figure 14a. **Left.** Aerial image showing the existing amenities of AlYarmouk Block 1 **Right.** Highlighted are existing amenities as represented in the simplified model of Block 1.

Map data based on 2015 DigitalGlobe

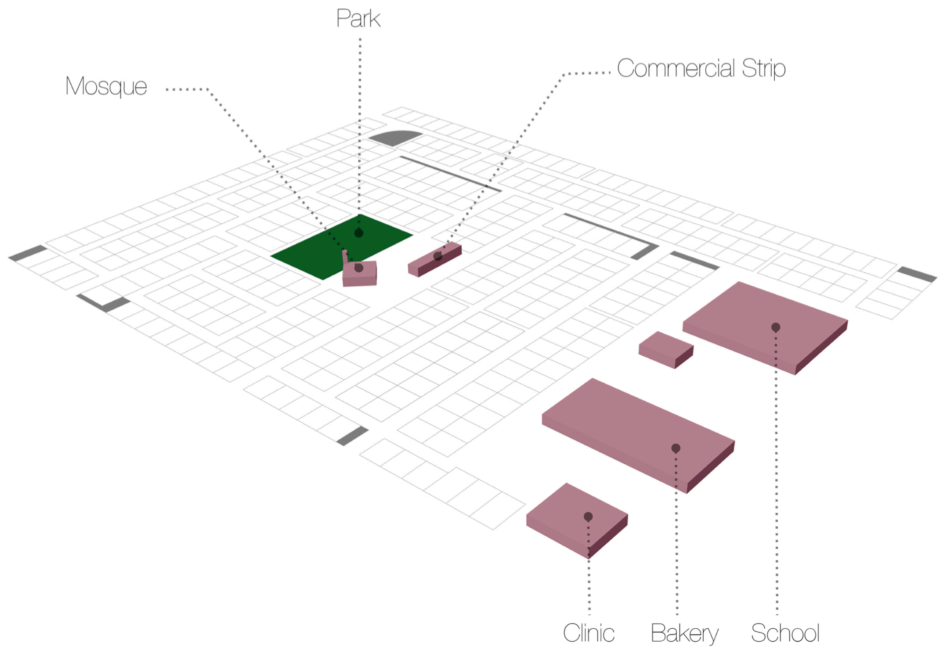

Figure 14b. Highlighted amenities of AlYarmouk Block1.

The two parcelization schemes (Parcel Scheme 1 and 2) of AlYarmouk were modeled with the grid of streets, possible sidewalks, and the amenities as they exist (Figure 14). The willingness-to-walk measure, defined in the walkable radius values, as well as the amenity table has been customized specifically to fit the case of Kuwait with respect to the influencing climatic conditions and the amenity categories. Using a 200-meter walkable radius as opposed to the North American standard of 400 meters showed that both schemes are highly car dependent (Figure 15). It can also be depicted that the flawed densification attempt (as explained in section 4.1) with the second-generation parcel types (PT3 and PT4) has in fact increased the car dependency of the neighborhood. The action of splitting the first generation parcel types resulted in the loss of bilateral access to streets and sidewalks, increasing the length of paths and concurrently impacting the reachability of parcels to amenities.

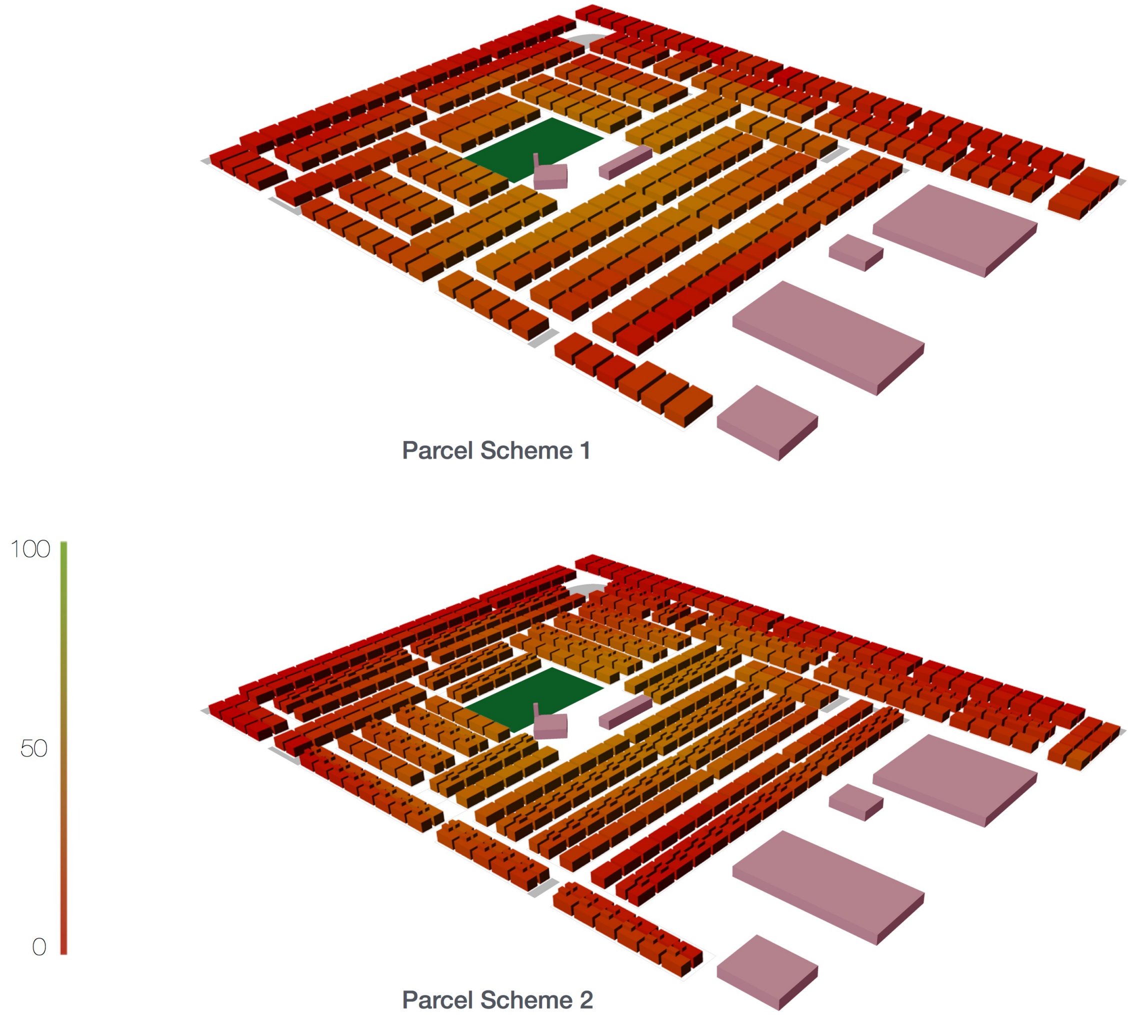

Figure 15. Highlighted amenities of AlYarmouk Block1 and UMI walkscore analysis of Parcelization Scheme 1 (**top**) and 2 (**bottom**).

4.4 **Outdoor Thermal Comfort**

Urban planning regulations have also been found to influence not only urban form spatially and the individual building performance as discussed in the previous sections but similarly the apportioned micro-climate of the urban area. The formed urban micro-climate is a product that is highly correlated to the development rules and regulations and hence structures the immediate environment of individual buildings (Givoni, 1998). That said, these code-determined urban forms could climatically affect both the outdoor and indoor environments especially through solar gain and wind speed. In terms of solar gain, the code has the ability to acclimatize buildings in summer and winter to allow for the desired surface absorption and reflection. Also, with particular urban configurations the code could enhance urban ventilation and promote passive building cooling systems through induced wind speed and direction (Johansson & Yahia, 2010). That being the case, regulating the built environment in a way that is conscious of its impact on micro-climate influences the performance of the previous evaluative measures; affecting energy consumption within the buildings as well as encouraging walkability within the neighborhoods.

Similar studies have made an obvious advantage in the use of numerical models compared to field measurements when considering controlled environments and time restrictions. Using the three-dimensional computational fluid dynamics model, ENVI-met, microclimate conditions were simulated and analyzed. To account for the discussion in recent studies debating that mitigation strategies for better air temperature may not necessarily have a positive impact on outdoor thermal comfort (Emmanuel, Rosenlund, & Johansson, 2007), this study investigated mean radiant temperature (MRT) as well as air temperature (Ta). Although other thermal comfort indices considering wind speed and humidity are acknowledged, they are earmarked for future studies coupled with actual thermal perception investigations.

The input data required to initiate the simulation model included geometric and physical properties of the urban arrays as well as geographical and metrological data (referenced to AlYarmouk Block 1). For both parcelization schemes, the same area excerpt was selected to meet a suitable spatial resolution within the maximum allowable scale. The area excerpt is shown in Figure 16 and results in a 400 × 400 m area with a height of 30 m at a 2 m resolution (the maximum allowable is a grid cell of 250 × 250 × 30 with a horizontal resolution between 0.5 and 10 m). The tested urban arrays were the *centered* and *central void* typologies in both parcelization schemes. The buildings were modeled as blocks and dimensioned by multiple grid cells with equivalent indoor temperatures, albedo and thermal transmittance values to be constrained solely by their spatial distinction. Also, surfaces were modeled as either natural or paved and vegetative covers were disregarded due to their absence within the code and hence considered out of the scope of this research. Meteorological input data were retrieved from the nearest weather station, Kuwait International Airport, and the basic input configuration from available documentation and comparable published research (Table 4).

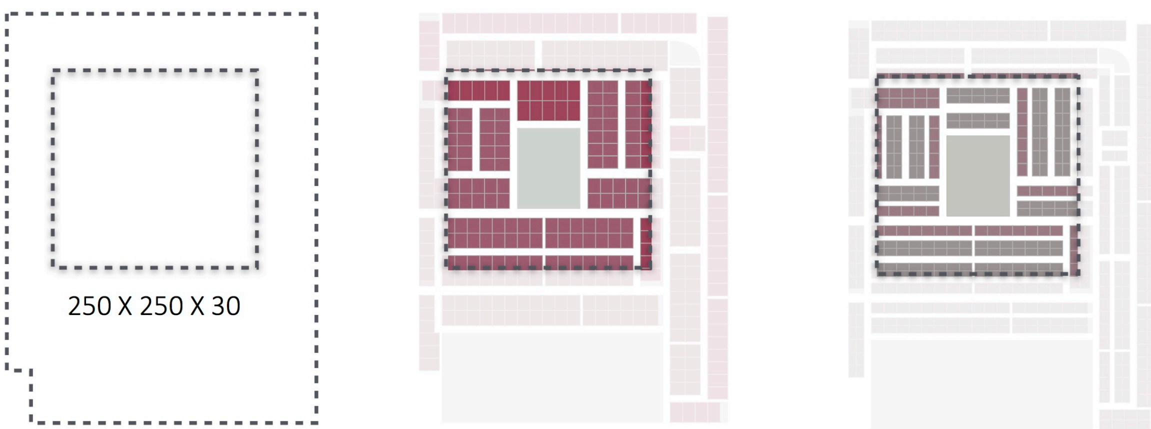

Figure 16. Left. The maximum allowable grid cells within the boundaries of the simplified Block 1 of AlYarmouk. **Middle and Right.** The selected area within parcelization schemes 1 and 2 respectively.

The simulation carried out in this study was on the 21st of June as it is the longest day of the year and a month of maximum-recorded average temperature. The simulation period was set for 24hrs beginning at 4:00 am to be able to calculate diurnal temperatures and observe warming and cooling hours of the day and night.

The wind speed was set to an average of 9.25 m/s at a 10m height, as obtained from the Airport weather station, and predominantly directed from the North West. Soil conditions rose incrementally starting at 15% with a constant temperature of 300 Kelvin.

Table 4. Basic configuration data for the ENVI-met simulations.

Start/Duration of Model Run		
Start Date	06.21.2015	
Start Time	4:00:00	
Total Simulation Time	24hrs	
Meteorological Conditions		
Wind Speed (10m ht.)	2.56 m/s	
Wind Direction	315° (NW)	
Atmospheric Temperature	38.63 °C (calculated through forcing)	
Specific Humidity	1.47 (g/kg at 2500m ht.)	
Soil Conditions	Relative Humidity (%)	Initial Temperature (K)
Upper Layer (0-20cm)	15	300
Middle Layer (20-50cm)	20	300
Deep Layer (50-200cm)	25	300

As explained, the two parcelization schemes were tested using the centered and the central void typologies (Urban Arrays 1, 2 and 5 – refer to Figure 10). The physical configuration of each referenced array is modeled in ENVI-met as shown in Figure 17. The illustration demonstrates that with a plan view it is enough to depict physical dissimilarities in terms of density, enclosure and proportion.

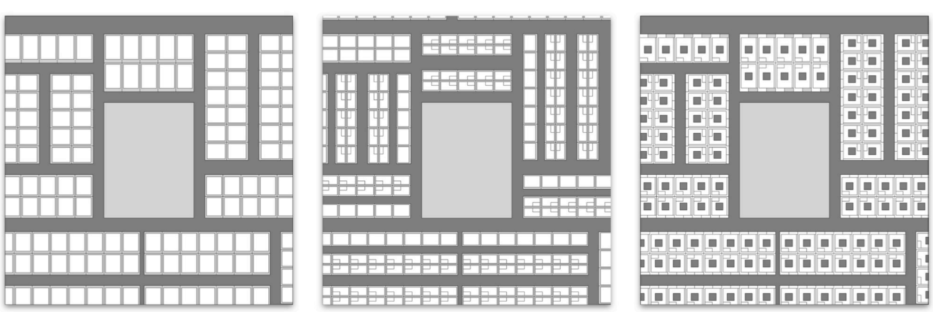

Figure 17. The urban array excerpts as modeled in ENVI-met. From left to right, Urban Array 1, 2 and 5.

In terms of average MRT, when comparing the urban arrays amongst each other, Urban Array 5 has the highest average simulated MRT, whereas Urban Array 2 has the lowest (Figure 18). This can be explained using the surface area to volume ratio. Array 5, central void typology, has the greatest surface area and hence a higher ratio that yields higher heat gain during the summer and heat loss during the winter (Sthapak & Bandyopadhyay, 2014). At the same time when comparing the arrays to their total simulated average, and treated as a base case, similar findings can be concluded (Figure 19). It is also worth mentioning that a tradeoff is often initiated with high surface area to volume ratios as it increases the possibility of attaining desired day lighting and natural ventilation.

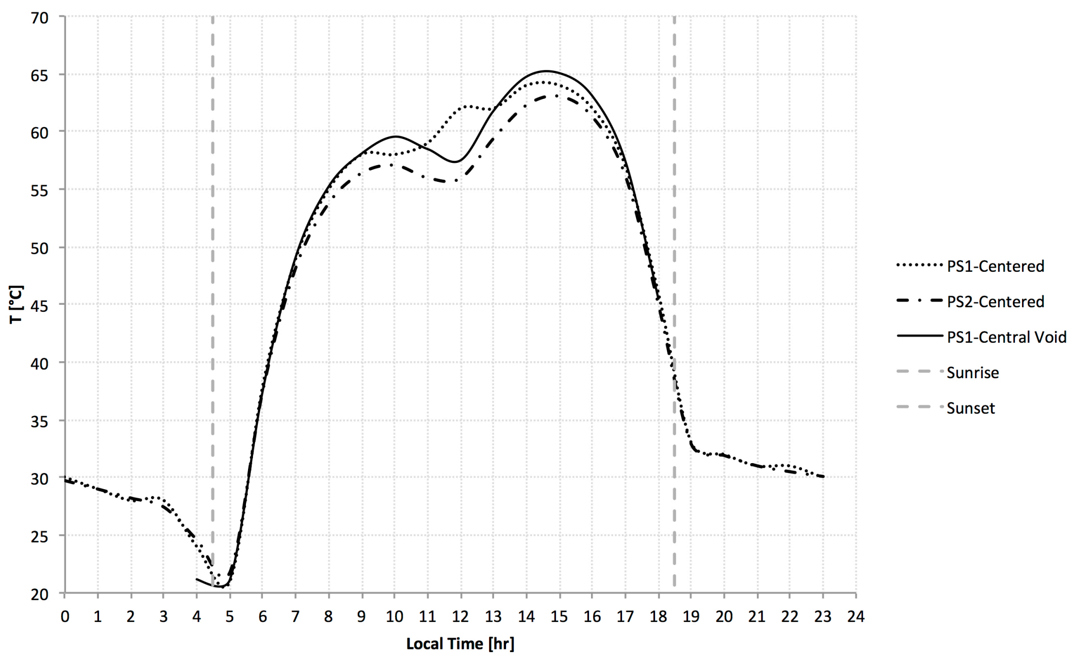

Figure 18. Average simulated MRT for Urban Array 1 (PS1 – Centered), Urban Array 2 (PS2 – Centered) and Urban Array 5 (PS1 – Central Void).

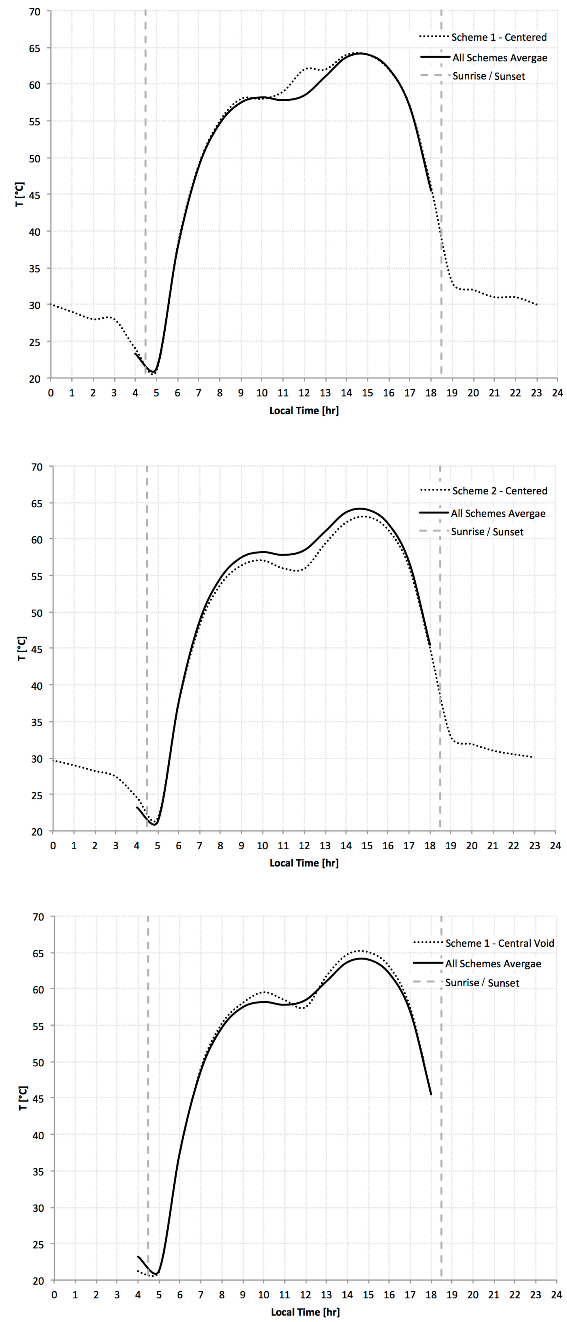

Figure 19. Average simulated MRT for each urban array compared to the total combined simulated average.

Simulation results were also analyzed in terms of diurnal air temperature at 1.8 m height for the three arrays. Opposite to that of MRT, findings using air temperature showed that Urban Array 5 has the lowest air temperature during the mid afternoon and Urban Array 1 had the highest (Figure 20). This case clearly demonstrates the critical tradeoffs that ought to be considered when trying to mitigate the shortcomings of regulations and take into account multiple evaluating parameters. For instance the advantages of the courtyard typology, as applied in Urban Array 5, when looking at air temperature, could offset its disadvantages due to its large surface area especially with the stack effect phenomenon and its ability to induce cross ventilation. This is also determinant of the aspect ratio, where within the courtyard typologies when the void is narrow and surrounded by high walls – low aspect ratio – solar access is minimized. Analogous to the comparison method with MRT, in comparing the simulated air temperature of the urban arrays individually to the total average, Urban Array 5 has the coolest air temperature (Figure 21). The differences found in the location of heat and speed or intensity of heating up and cooling down between the three arrays (Figure 22) is useful to further examine air temperature with the presence of vegetative covers of which is part of future planned studies.

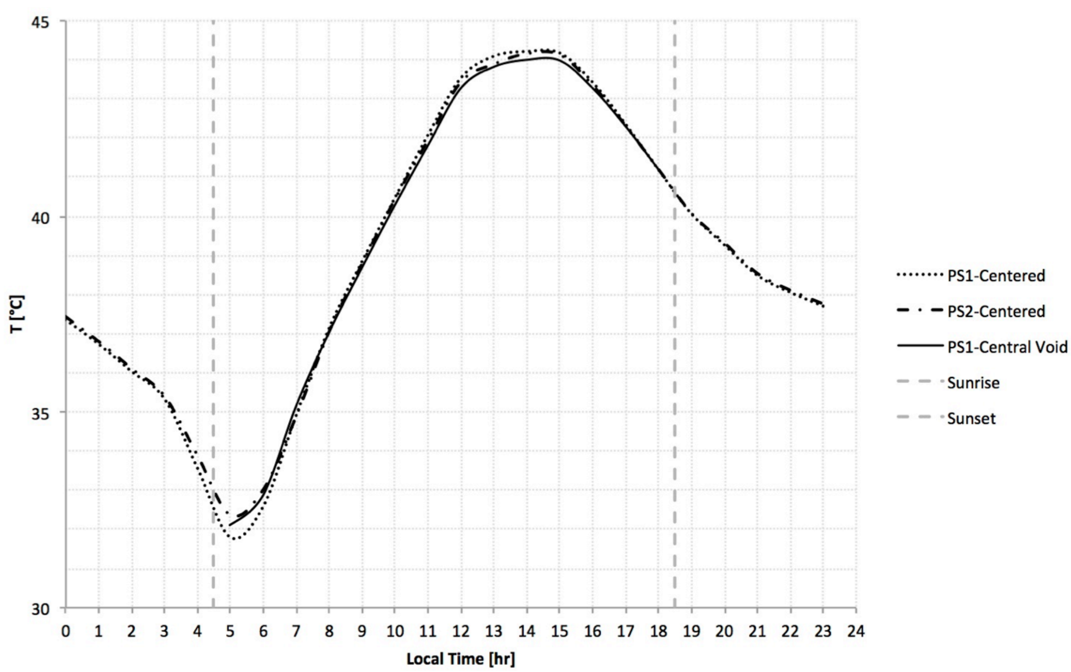

Figure 20. Average simulated air temperature at 1.8 m height for Urban Array 1 (PS1 – Centered), Urban Array 2 (PS2 – Centered) and Urban Array 5 (PS1 – Central Void).

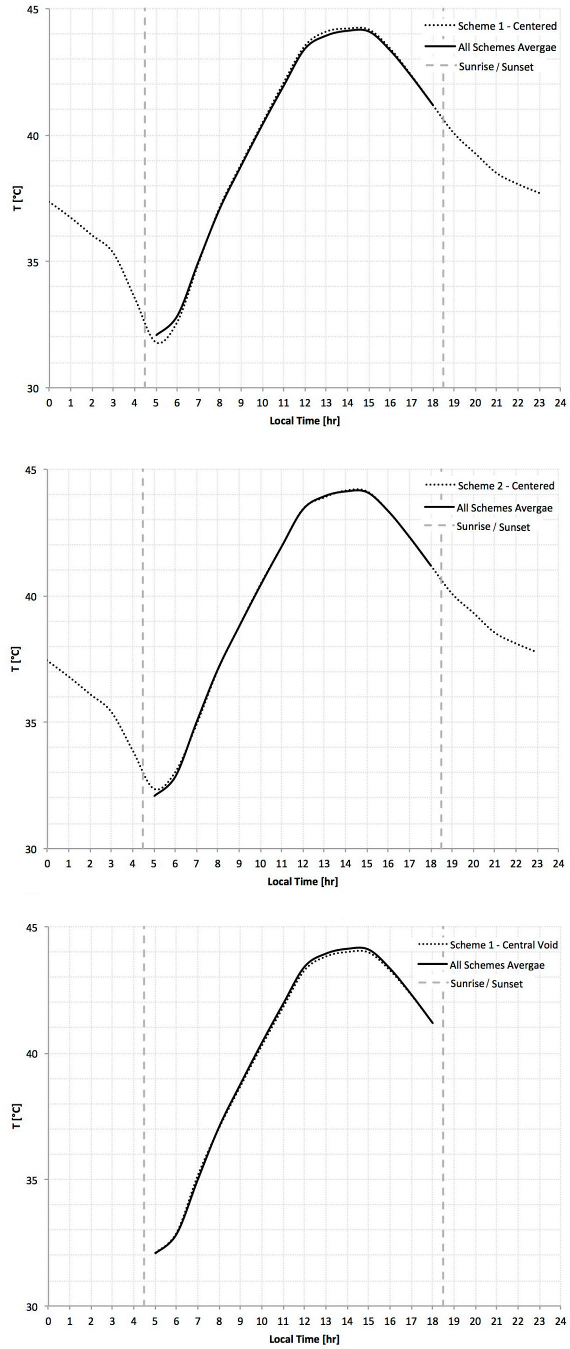

Figure 21. Average simulated 1.8 m air temperature for each urban array compared to the total combined simulated average.

Having only marginal thermal differences among the typologies actually stands as a support to this thesis by concluding that current planning regulations, as found in the KBC, are restrictive to a predefined urban texture of poor performance and in need of revision. It illustrates that with such prescribed typologies and current configurations, no significant effect is found between deep forms of greater density and shallow forms of less density. It recommends more space within the Code to orient developments and permit certain configurations that would allow greater mutual shading when required. Shade could also be introduced with the manifestation of Green Area Ratio as a regulation that requires minimum local vegetative covers and improves thermal comfort through other ecological services it also provides with its presence.

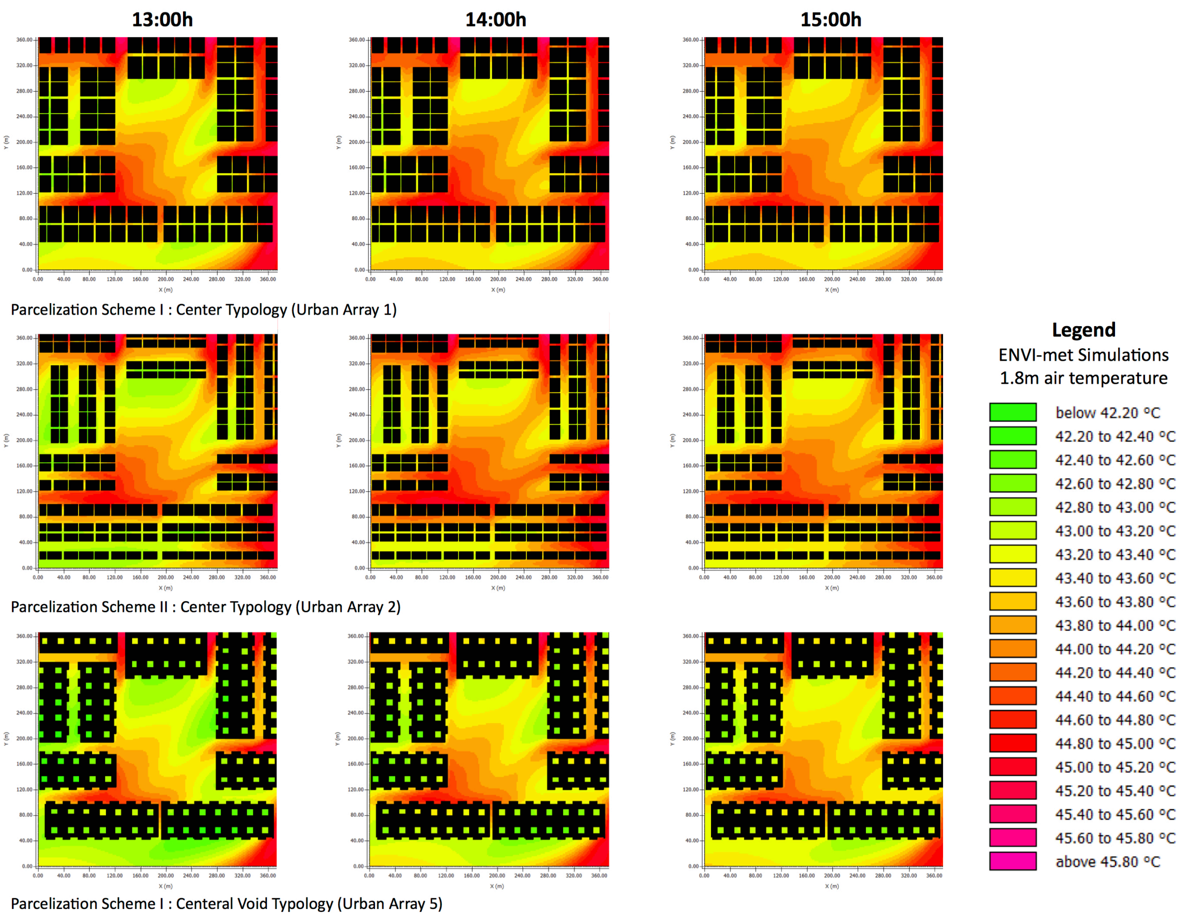

Figure 22. Simulated air temperature distributions at 1.8 m height for each urban array at hours 13:00 -15:00.

Chapter 5

Conclusion & Propositions

This study has proposed an initial framework to assess the impacts of inherited building regulations using Kuwait as a case study of a master-planned city. After tracing urban governance history and determinations, and the planning of and for building legislation in Kuwait, it proposed expanding on the simplification process of Martin and March into a framework to develop generic building typologies into building-code-compliant archetypes and theoretical urban arrays to perform comparable virtual analysis. Using selected performance metrics, the study framed the debate of ill-suited regulations using a simulation study. The findings evaluated the impacts of code-determined urban forms within the detached residential urban environment in Kuwait. It proves that present urban challenges are confounding variables to ill-suited regulations buried in the applications of extraneous foreign standards that remain important and of consequence due to the burgeoning environmental and climate change risks the region is experiencing.

In surveying the theoretical debates of environmental and social impacts resulting from urban governance, the *Theory of Regulating Urbanism* (section 2.1.1) presented the inconsistency between the desired and realized values contained within the KBC. Different values guided the authors of codes to deliver the many visions of urban form, each influenced by their beliefs on how we ought to live, and often incompatible with the defined urban form. In delivering the different values, urban form either suffered from unclear intended purposes or unintended consequences opposing their primary determinations. This resulted in an escalating discontent in regulating urban formation and thus stimulated intense reform efforts. Much of these debates qualitatively prescribed alternatives that span between relating built forms to urban contexts, defining human habitats in relation to urban character, promoting accessibility by enclosure, and minimizing waste by challenging pseudo efficiency. The discussion, albeit widely expressing the discontent of ill-suited urban regulation, has not performed enough empirical testing to these undesired proposals. As a result, this thesis aimed to minimize the gap in the literature by providing a novel framework to simulate the physical functioning of urban codes and evaluate their impact on the performance of the built environment.

The uneven results of the urge to reform the congested city and "modernize" urbanization also presented a challenging issue of global urban monotony. The adoption of universal planning ideals and international standards has almost always tended to replace the supremacy of society, culture and physiography in determining urban form, and, unintentionally or not, diminish aspects of local urban variation. *Regional Place-Responsive Urbanism* (section 2.1.2), discussed not only the physical manifestation of traditional Islamic built environments but more importantly identified how it was a response to the residents' needs in both function and performance. Although it can be argued that they were still governed by codes and customary laws, their operationality (generative as opposed to descriptive) and understanding of urban growth/change processes is what demonstrates their contrast from contemporary urban codes. It stressed the way in which revisiting and testing the urban components, spatial organization and architectural qualities that composed traditional urbanism would allow the emergence of reconciling place-based development schemes.

The literature review on the notions of Regulating Urbanism culminated with a synthesis of *Impact Evaluation Measures and Metrics* (section 2.1.3). It revised the various evaluation approaches towards achieving optimal urban form as found in the literature to postulate common evaluative measures and bridge the absent concurrence among the interrelated assessing disciplines as determined by specialty. It found that, despite the absent consensus towards an integrated performance matrix, the general assessment model pertains to the physical structure of desired urban forms irrespective of scale and methods. The review presented the way in which, at the precinct scale, available assessment tools tend to be prescriptive solutions rather than comprehensive answers to the problems of actual and intended urban performance. The available scholarship framed the evaluative metrics of urban performance from competence in utilization, operation and microclimates as deployed in the simulation approach of this study.

Unique insight into Kuwait's urbanization process was presented in *Planning Kuwait* (section 2.2). Using archival research, the review of visual records and narrative documents exposed Kuwait as an exemplary case study when recognizing its rapid transition of a once-local urban form under imported urban frameworks. The section traced early records of the Kuwaiti Building Code and the arrival of the Neighborhood Unit to map the transition under the influence of extraneous ideals. Tensions that emerged from adopting 'universal' planning ideals were revealed and formed a link to the disregarded factors that were inherent to urban form.

The Simulation Framework began with the sampling procedure employed in selecting a site that resembles an appropriate sample to this investigation (3.1 *Site Selection*). AlYarmuok, the site, was then followed by Martin and March's (1972) simplification and classification process of urban form (3.2 *Simplification Process*). It underwent a classification method that defined and combined **(a)** 4 parcel types with **(b)** 4 generic building typologies to develop a simplified set of **(c)** 16 archetypes within **(d)** 8 urban arrays of **(e)** 2 parcelization schemes. The method extenuated a significant lack of data in the current housing stock of Kuwait, permitting an evaluative simulation of the KBC impact on the performance of the built environment in a comparable analysis.

An experimental workflow with UMI and ENVI-met was used in the modeling of the theoretical urban arrays to simulate performance with respect to land utilization, operational energy, design accessibility, and microclimate variations. *Floor Area Ratio* (section 4.1) found that the practiced densification measures as regulated by the KBC are flawed. It suggested that it would be helpful to revisit the combinations of parcel types to achieve the intended density within the neighborhood units, as well as revising the physical parameters of the code such as the setbacks and allowable frontages. *Operational Energy* (section 4.2) showed that the centered typology outperforms the rest and the larger parcel types outperform the smaller, which supports the use of deeper urban forms in hot-arid climates. A set of typology-specific architectural elements is recommended to enhance the performance of other typologies coupled with testing the impact of hybrid patterns in the use of passive and active systems.

By testing the two parcelization schemes, *Accessibility* (section 4.3) demonstrated how both are car dependent and introducing the second generation parcel types has in fact increased the car dependency of the neighborhoods. In order to lessen the apparent auto-dependency, the section recommended testing different urban configurations that could influence individual preferences of travel with an increase in available amenities. Finally *Outdoor Thermal Comfort* (section 4.4), particularly investigated air temperature and concluded that minimal differences were apparent among the urban typologies. It found that the restrictions set by the KBC are generating a predefined urban texture of poor thermal performance and are the main factor in the consistency of the results. It requires location specific configurations that respect building orientation to allow greater mutual shading when required, as well as introducing minimum vegetative covers to improve thermal performance.

This research did not aim to contribute as a polemic about the failure of contemporary codes, nor does it present the perfect urban code model; but instead aims to bring a new platform that marks building regulations as positive determining factors within the process of urban formation. Indeed, the study suggests the development of a system of classifications and local urban performance indicator matrices able to query implemented standards and their future applications. Such a matrix requires an interdisciplinary approach through an array of lenses to prevent tendencies of biased masking. Ultimately, it would demonstrate the consequences in the application of versatile principles to specific locales at the cost of urban quality and demand on regulations that would promote honest urban forms responding to local requirements.

In short, the words of Lewis Mumford sum up the guiding principles behind this research: “In the end, I promise, I shall make no attempt to present another utopia; it will be enough to survey the foundations upon which others build” (1962, p. 26).

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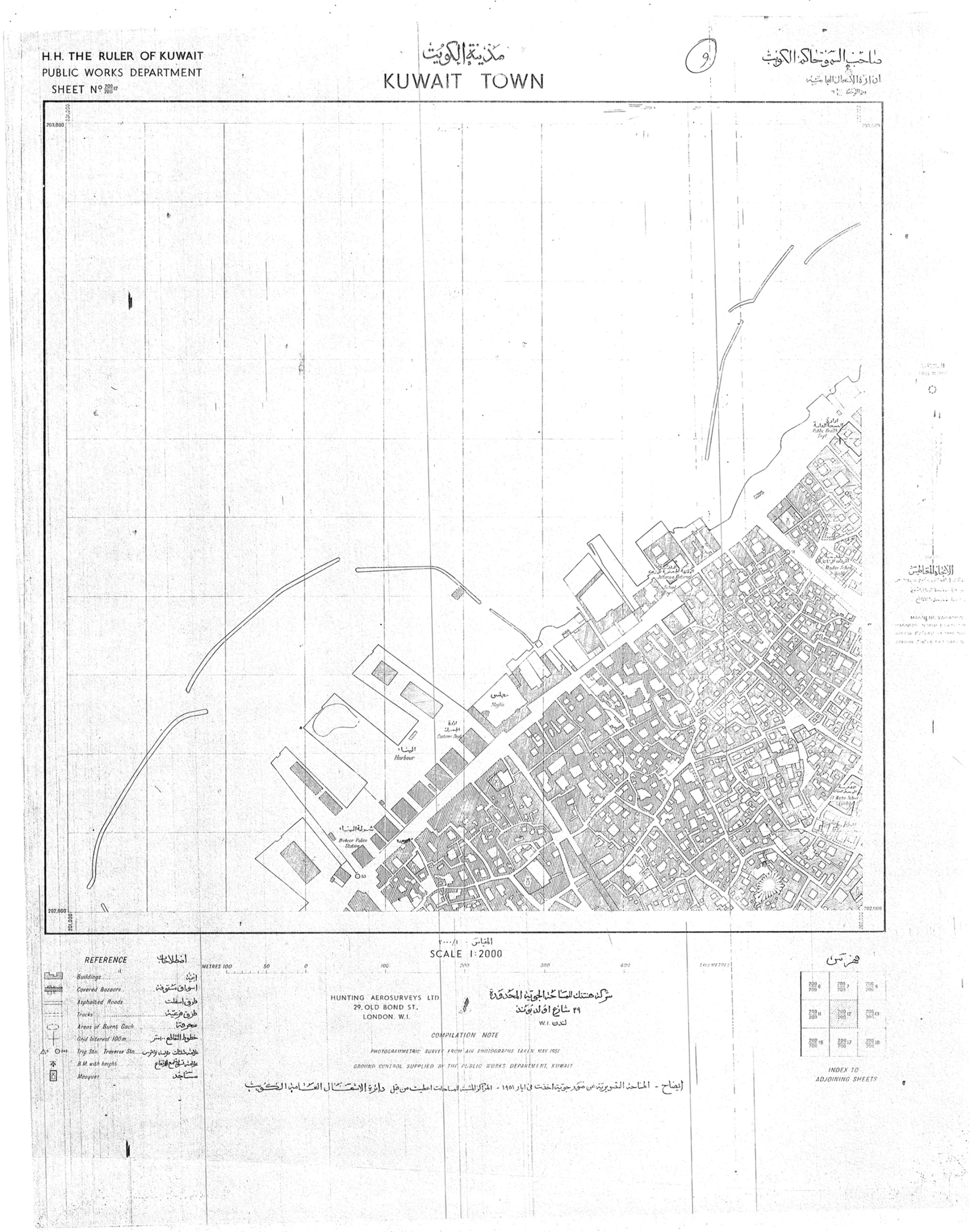
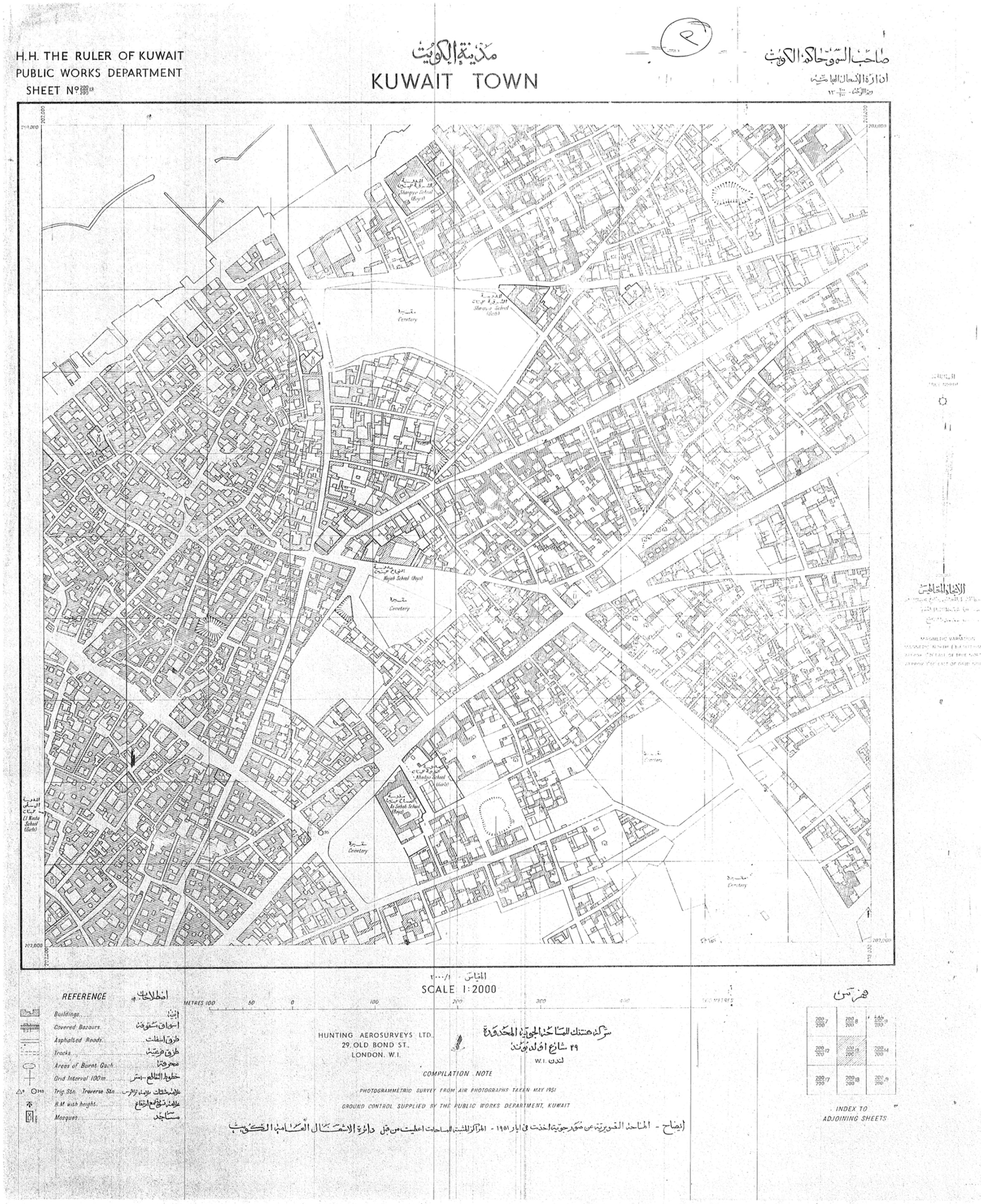
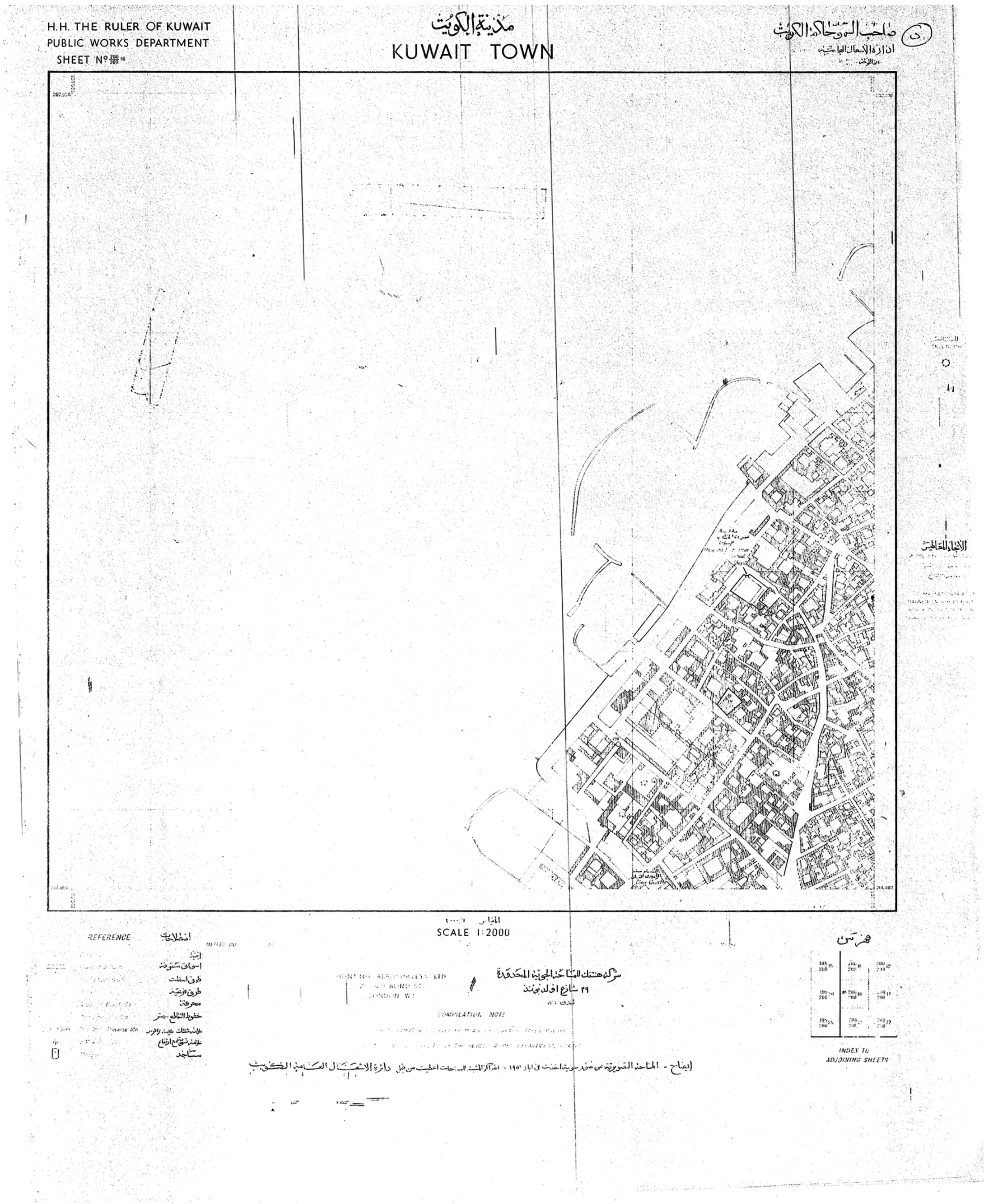
APPENDIX A

HUNTING AEROSURVEYS 1951: PHOTOGRAMMETRIC SURVEY OF KUWAIT FROM AIR PHOTOGRAPHS (SHEETS: 12,13,16,18,21)

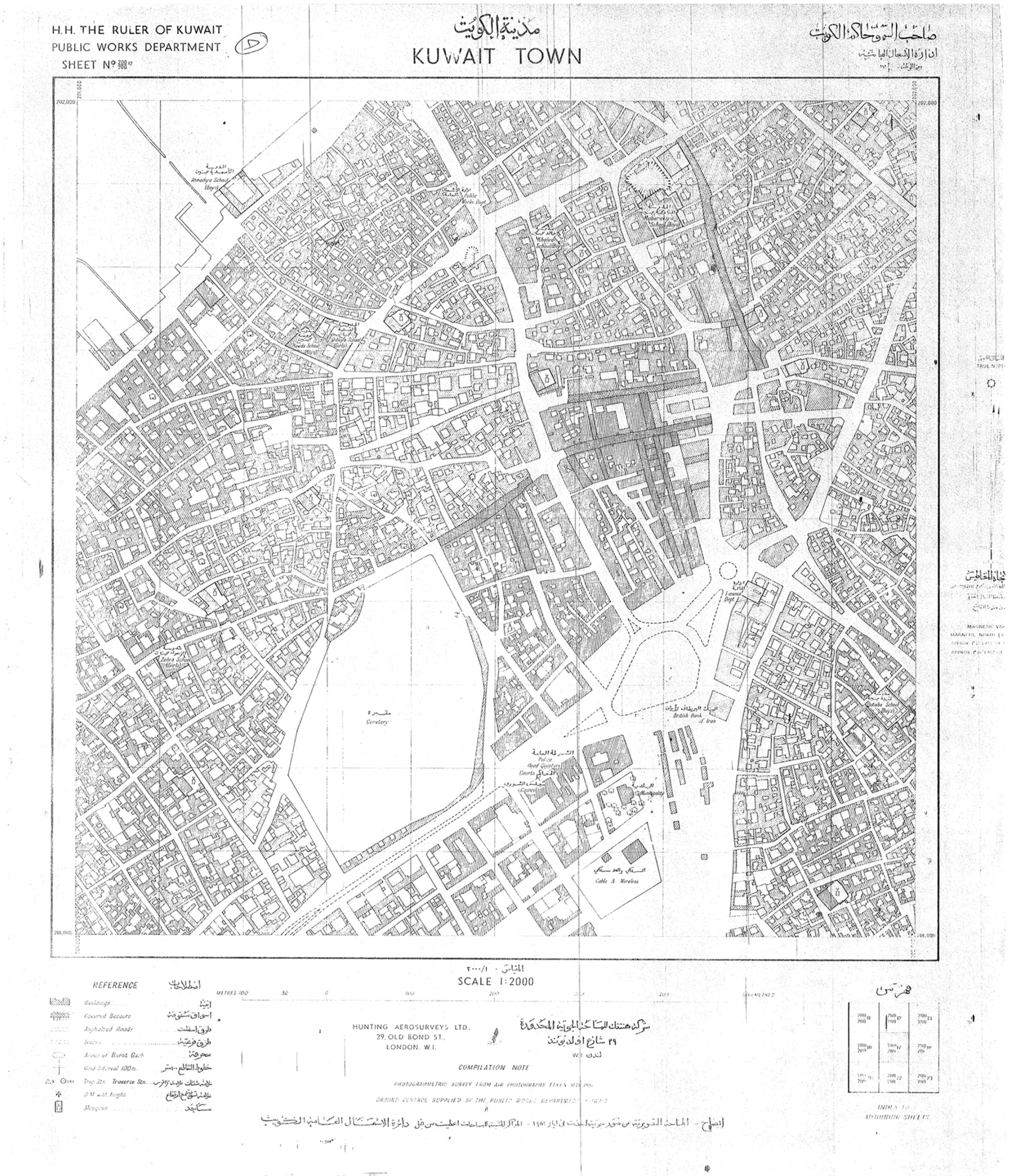


H.H. THE RULER OF KUWAIT
PUBLIC WORKS DEPARTMENT
SHEET No
مدينة الكويت
KUWAIT TOWN
Harbour
SCALE 1:2000
REFERENCE
HUNTING AEROSURVEYS LTD
29, OLD BOND ST.
LONDON. W.I.
COMPILATION NOTE
INDEX TO ADJOINING SHEETS


H.H. THE RULER OF KUWAIT
PUBLIC WORKS DEPARTMENT
SHEET No
مدينة الكويت
KUWAIT TOWN
Cemetery
Mujab School (Boys)
Cemetery
Cemetery
Cemetery
المقياس ١/٢٠٠٠
SCALE 1:2000
METRES 100
50
0
100
200
300
REFERENCE
اصطلاحات
Buildings ...... ابنية
Covered Bazaars ...... اسواق مسقوفة
Asphalted Roads ...... طرق اسفلت
Tracks ...... طرق فرعية
Areas of Burnt Gach ...... محروقة
Grid Interval 100m ...... خطوط التقاطع ١٠٠ متر
Trig. Stn. Traverse Stn. ......
B.M. with height ......
Mosques ...... مساجد
HUNTING AEROSURVEYS LTD.
29, OLD BOND ST.,
LONDON, W.I.
شركة هنتنك للمساحة الجوية المحدودة
٢٩ شارع اولد بوند
لندن W.I.
COMPILATION NOTE
PHOTOGRAMMETRIC SURVEY FROM AIR PHOTOGRAPHS TAKEN MAY 1951
GROUND CONTROL SUPPLIED BY THE PUBLIC WORKS DEPARTMENT, KUWAIT
ايضاح - المساحة التصويرية عن صور جوية اخذت في ايار ١٩٥١ - المراكز المثبتة للمساحات اعطيت من قبل دائرة الاشغال العامة الكويت
فهرس
INDEX TO
ADJOINING SHEETS



H.H. THE RULER OF KUWAIT
PUBLIC WORKS DEPARTMENT
SHEET Nº $\frac{200}{205}$ 16
مدينة الكويت
KUWAIT TOWN
SCALE 1:2000
REFERENCE
COMPILATION NOTE
INDEX TO ADJOINING SHEETS


H.H. THE RULER OF KUWAIT
PUBLIC WORKS DEPARTMENT
SHEET No
مدينة الكويت
KUWAIT TOWN
Cemetery
British Bank of Iran
Cable & Wireless
REFERENCE
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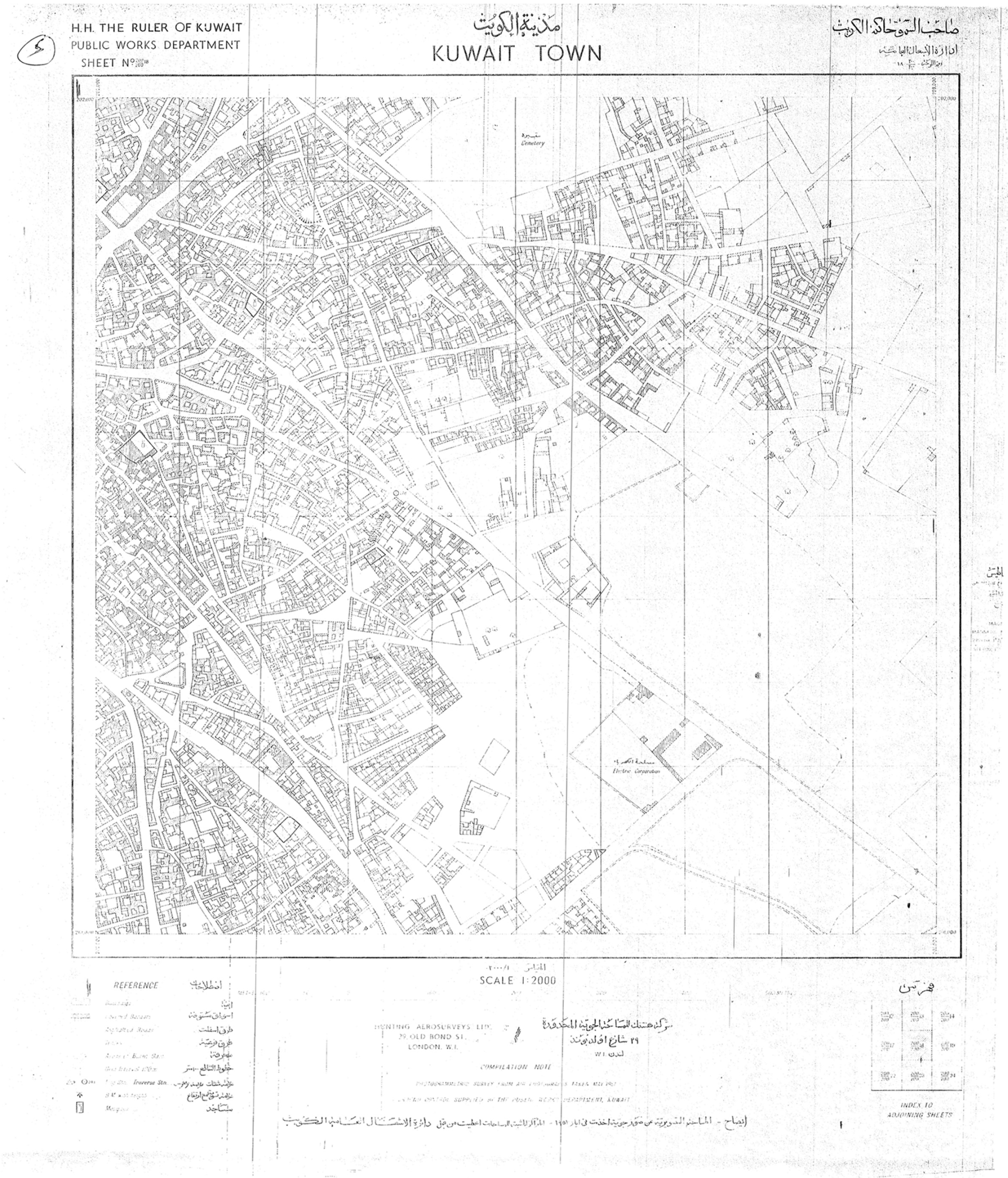
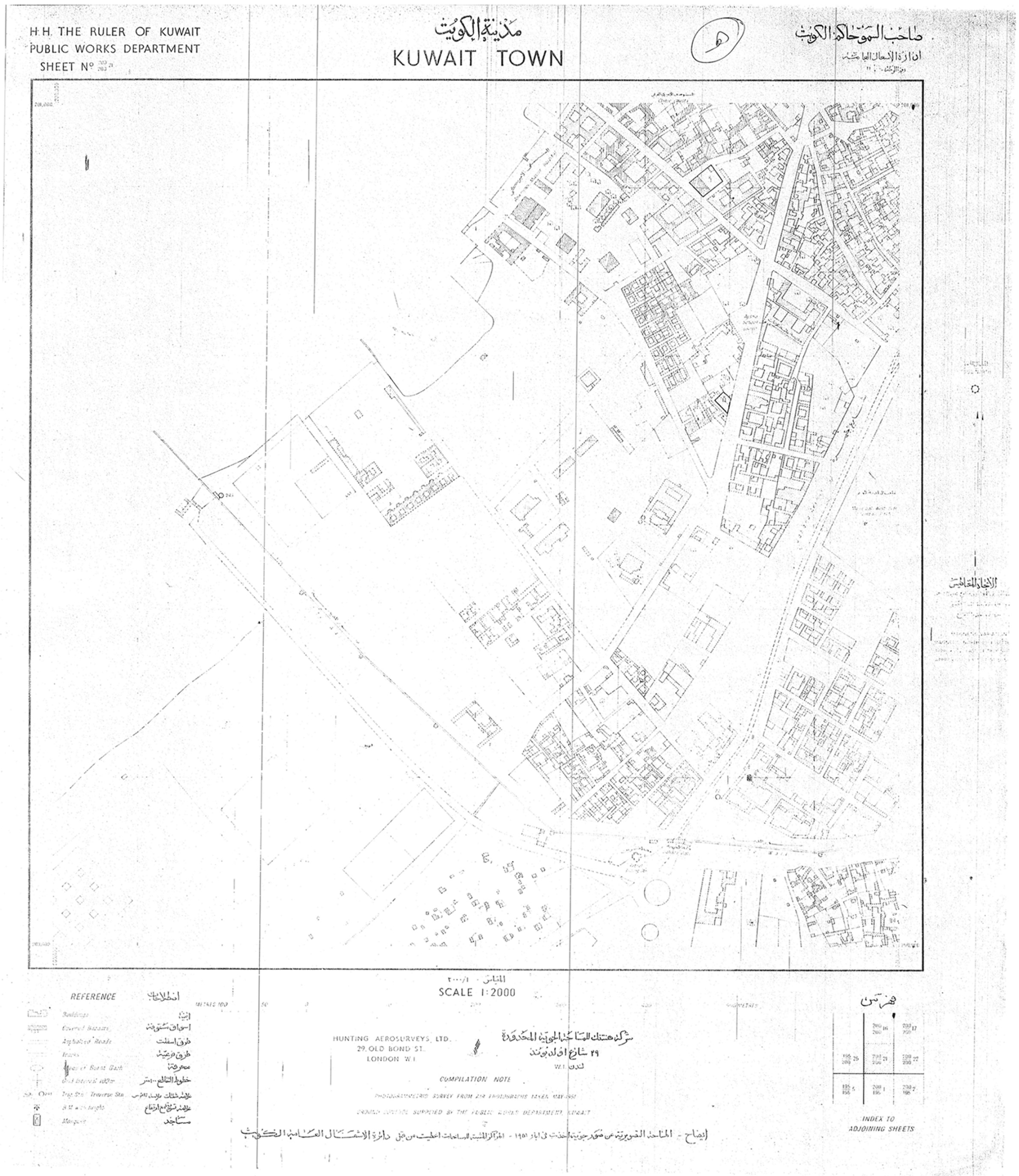
29, OLD BOND ST.
LONDON, W.1.
COMPILATION NOTE


H.H. THE RULER OF KUWAIT
PUBLIC WORKS DEPARTMENT
SHEET No.
مدينة الكويت
KUWAIT TOWN
Cemetery
Electric Corporation
REFERENCE
SCALE 1:2000
HUNTING AEROSURVEYS LTD.
29 OLD BOND ST.
LONDON, W.1.
COMPILATION NOTE
INDEX TO ADJOINING SHEETS


H.H. THE RULER OF KUWAIT
PUBLIC WORKS DEPARTMENT
SHEET Nº
مدينة الكويت
KUWAIT TOWN
صاحب السمو حاكم الكويت
ادارة الأشغال العامة
المقياس ١/٢٠٠٠
SCALE 1:2000
REFERENCE
اصطلاحات
Buildings
Covered Bazaars
Asphalted Roads
Tracks
Grid Interval 100m
Mosques
مساجد
HUNTING AEROSURVEYS LTD.
29, OLD BOND ST.
LONDON W.1
٢٩ شارع اولد بوند
COMPILATION NOTE
PHOTOGRAMMETRIC SURVEY FROM AIR PHOTOGRAPHS TAKEN MAY 1951
GROUND CONTROL SUPPLIED BY THE PUBLIC WORKS DEPARTMENT, KUWAIT
فهرس
INDEX TO ADJOINING SHEETS